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THE ADVANCEMENT OF ENGINEERING IN RELATION TO THE ADVANCEMENT OF SCIENCE[1]

THE term engineering is employed with many different shades of meaning. Tredgold's famous definition of civil engineering, which appears in the charter of the Institution of Civil Engineers (London), dating from 1828, commences with the excellent phrase—"the art of directing the great sources of power in nature for the use and convenience of man." In Tredgold's time, there were only two recognized types of engineering—*i.e.,* civil and military. At the present time, nearly forty different branches of engineering have been itemized in technical literature. For the purpose of this discussion, the following broad definition is suggested to cover all types of non-military engineering: *the economic application of the sciences to construction, production or useful accomplishment, especially on a large scale.*

From this point of view engineering manifests itself as the activating principle in the industrial world. Engineering, in this sense, must not only be coeval in antiquity with civilization; but the degree of engineering attainment in any age must also necessarily be an index or criterion of its civilization, judged from the material aspect.

If, as has been claimed by many writers, the acquisition and first permanent maintenance of fire marked the dawn of civilization in the early history of mankind, it would have been the province of the nascent engineering of that time to make a study of the laws of heat and combustion towards the maintenance and distribution of fire in tribal communities. To primitive man, the science of combustion may well have seemed extremely difficult, elusive and complex. The first rational notions on the subject were probably mingled with many errors and superstitions. These psychological stumbling blocks may have hampered and hindered, for many centuries, the attainment of the degree of thermal scientific knowledge appropriate to man's mental and moral development of that period.

Coming down to early historic times in ancient Egypt, we find a considerable increase in scientific knowledge and its application by engineering, confided to a priestly caste. The sciences were assidu-

[1] Address of the vice-president and chairman of Section M—Engineering, American Association for the Advancement of Science, Kansas City, Mo., December 30, 1925.

ously studied, and the knowledge thus acquired was jealously guarded by the esoteric. Considering how large, in the aggregate, are the literature, the statuary and the painting of ancient Egypt that has been preserved to our own times, it is remarkable how few of their scientific records have been found. Taking into account their temples, pyramids, monoliths, canals, ships and metalwork, it is clear that their scientific knowledge was in highly developed application.

In ancient Rome, the keynote of her empire was military power. She explored the sciences mainly for knowledge concerning armaments. Her great system of roads was primarily a system of military communication, for the most part constructed and maintained by the legions, often with the slave labor of conquered peoples. Engineering was chiefly in the hands of military officers, who specialized in various branches of construction. Their scientific knowledge was mainly of a practical kind, and their measuring instruments were relatively crude, but their engineering achievements were considerable, thanks to a national aptitude for practical accomplishment.

Through the middle ages and renaissance, art flourished; but engineering made little progress. Production remained in the hands of crafts and guilds. These developed great manual skill, but scarcely advanced the underlying sciences. Only in canals, shipbuilding and masonry construction, did notable advances occur. Engineering, recognized under that title, was practically confined to military works.

The present era, which is essentially an engineering age, may be said to date from the introduction of the steam engine, and in that sense is only about one hundred years old. The application of the science of heat, in relation to steam for generating power, rapidly changed the nature of production from the individual-worker system to the factory system, augmenting greatly the output of a day's work. This in turn brought new dense factory populations, and also brought the means of supporting them. The so-called industrial revolution, thus started, brought tremendous sociological changes in its wake. Rapid steam transportation accelerated commerce and developed markets. It enabled producers to find sales for their products over a continually enlarged area. A sense of economic emancipation dawned over mankind.

During the middle ages and renaissance, the study of science was slowly advancing in the western world, mainly under the guidance of the universities. This study consecutively followed the growth of mathematics and was seldom directed to engineering applications. The natural philosophers, chemists and mathematicians who lived in the early years of the nineteenth century taught and worked in intellectual regions usually remote from applications to utility. The rapid growth of the steam engine for driving factory machines, in the early years of the engineering era, brought into existence the mechanical engineer, who received his training in the workshop and factory. The mechanical engineer was compelled to study the nature of heat engines and of combustion, the laws of mechanics and the properties of machines. This scientific study was, at first, more or less empirical and unsystematic. In the early days of mechanical engineering, the physicists and scientists were ordinarily so far removed in their experiences from machines and engineering that they saw no way of cooperating with the engineer; while the engineer was so completely engrossed with the practical details of his work that he could see no way of receiving help from theoretical science.

The last few decades have steadily drawn together these two types of men and schools of thought by mutual modification. The constantly increasing scale of machinery and machine production has necessitated more concentrated scientific study of the principles involved. The engineering applications have demanded more scientific knowledge, and the scientists have become more interested in applications. Until about fifty years ago, the initial training of a young engineer, after leaving school, was either by apprenticeship to an engineering workshop, or by being articled, as an assistant, to a practising engineer. It is now recognized that the best training is in an engineering school of a university or technical college, where special study is devoted to the fundamental arts and sciences, followed by technical or applied science in some particular branch.

It is not only in the particular fields of engineering that this close dependence of application upon the sciences has become essential; but also in manufacturing and general production. It may be safely asserted that manufacture, on a large scale, is so closely associated with engineering processes as virtually to become engineering itself. In other words, in order to carry on manufacture economically, on a large scale, the process is practically the same as engineering. There is the same need for scientific study of the principles and basic materials involved, the same need for careful and thorough design, with a view to eliminating waste in material, plant or labor, the same need for experience and skill in the various stages of the work, and the same necessity for careful preliminary estimates of cost, as well as of checking the cost in successive stages.

Every labor-saving appliance in manufacture, and every scientific improvement introduced into its procedure, is a new evidence of the identity between

modern manufacture and engineering. A manufacturing community, in modern times of competition and development, is of necessity an engineering community.

Prior to the amalgamation of science and industry in our present engineering age, the advancement of science was made mainly in places where science was studied and taught; *i.e.,* in universities, or institutions of scientific learning associated therewith. Since the amalgamation, however, an increasing share in the advancement of science has been carried on in engineering establishments, *i.e.,* in industrial laboratories, in factory laboratories or in government and state laboratories. A large amount of scientific investigation is nowadays carried on in such institutions, either partly or wholly for economic and industrial advantage. It becomes the duty of scientific societies to collect, correlate and preserve this scientific knowledge, which otherwise might become lost and forgotten. In future, the advances of engineering and of the sciences upon which engineering depends, will be so bound up and interconnected, that whatever gives one a step forward must also give a like impulse to the other.

It would no longer be possible to maintain the huge populations of many large cities in the world, without engineering, *i.e.,* without the continued economic application of the sciences to the supply of the many products those cities require.

Although the needs of utility have in recent years either suggested or demanded numerous scientific researches, it is manifest that many other researches in the sciences are and will doubtless continue to be made exclusively for the truth's sake and independently of any specific utilitarian need. It is only necessary to consider any scientific subject in all its bearings to realize that this must be so. The great science of mathematics, for example, must evidently be greater than the sum of all its applications; so that unless all scientific curiosity as to the nature of new mathematical relations shall disappear, many investigations must continue to be made into branches of the subject that appear to have no immediate applications. Moreover, many cases of scientific research which have been made without any suspicion of applicability have subsequently come to be applied to very practical use. It would seem that the only differences which necessarily separate a scientific research of the basic or non-applied type from one of the applied type lie in the aims and motives of the researcher. In other words, one and the same research, conducted in the same way, will be an applied-science research or a basic-science research, according only to the purpose in the mind of the person who carries on the work.

It is generally conceded that researches carried on for the advancement of science tend strongly to stimulate the imagination. The investigator is called upon, at every stage of experimental inquiry, to speculate upon all the possibilities that present themselves and to set up a new test that may serve to demonstrate which are the actualities and which the unrealities. It is not so generally recognized, however, that the work of the designing engineer also makes special claim upon his imaginative powers in the material realm. Any new project, such as a large bridge, building, railroad or power plant, calls for a careful estimate and design. It has to be completely visualized, part by part, in the mind of the designer, before construction commences. The designer has then, either alone or with the aid of assistants, to realize his plans in two-dimensional drawings. A large project may involve the preparation of many hundreds of drawings, in advance of assembling the materials. All these drawings must interlock and connect in technique and dimensions. Tracings and blueprints from these drawings are then provided for guiding the constructors in their various tasks. The assemblage of design drawings embodies in most new undertakings a considerable amount of invention, imagination and creative work, which the builders proceed to translate from small scales in two dimensions to full-size three-dimensional reality. To the trained eye, a good construction blueprint reveals, under its network of lines, a wonderful image of reality.

In the engineering of building construction, provision is made for the proper conservation of esthetic grace by the profession of architecture. On its artistic side, architecture seeks to foster and promote the art of beautiful building construction. This professional attitude towards art in the engineering of buildings guides public opinion in such a way that graceless and inharmonious buildings seldom escape popular censure. In other branches of engineering, the esthetic quality of the product does not at present find similar professional safeguard. Nevertheless, there is, for each type of engineering construction, a certain somewhat indefinite standard of artistic appearance, below which the designers and builders are sure to encounter hostile criticism. In every country, new types of machines, which are experimental and have not yet established their right to survive, are usually revealed by their awkward appearance. Each country develops, as a general rule, its own type of esthetic standards in appearance, and experts frequently detect, in this way, the nationality of machines and the relative artistic engineering excellence of the nations in which those machines were produced. It is here again that the advancement of science reacts

upon advancement in engineering, because the harmony in nature that scientific study discloses tends to guide the minds of those who apply the great principles of nature to the satisfaction of human needs.

Just as the advancement of engineering construction, as, for instance, in telescopes, is constantly tending to the advancement of the sciences—or of astronomy in the case considered—so in return the advancement of science is constantly tending to the advancement of engineering processes. Thus, the precision of geodetic surveying has greatly increased during the last few decades, owing to progress in the sciences of astronomy, mathematics, physics, metallurgy, geology and others. Moreover, the demands made upon engineering design and construction tend ever to become more exacting. For example, it has recently been stated that the new Philadelphia–Camden bridge across the river Delaware is the first in which the supporting towers have had to be given extra strength to withstand the possible accidental impact of an aeroplane.

So close is the present interconnection between science and engineering that the only salient distinction between them lies in their respective relations to economics. Questions of cost inevitably present themselves in the study of basic scientific problems, if only as limitations to equipment; but they are ever present in the study of engineering problems. Indeed, engineering problems call for special methods of accounting and emphasize the importance of determining amortization, depreciation, effective rates of interest and present values of plants. The stocktakings of large-scale businesses likewise tend to become both economic and engineering inquiries.

As the entire civilized world becomes more and more given over to engineering, if only in order to support its large populations, it becomes evident that the conversion of factories for producing utilities into agencies for developing destructive and poverty-making warlike implements is ever easier. The power of science to create in the hands of those who help becomes equally the power to destroy in the hands of those who fight. The world has only to orecently seen how terribly destructive the powers of science and engineering can become in war among the industrialized nations. Modern war is engineering gone mad. This misuse is of course no fault of either science or engineering. If, however, in the reasonably probable advance of both, we are to avoid the utter destruction of civilization by war and the economic servitude of posterity in its wake, we must all unite in building an international organization that shall not only tend to prevent the onset of war but shall also swiftly suppress its first outbreaks. In any such organization, both science and engineering are sure to be powerful elements for effecting control. Under such control, once successfully established, the advancement of science and engineering should surely promote and maintain world peace. Even now all science and its applications are essentially international. No way has ever been found to make science operate exclusively for the benefit of one nation or portion of the globe.

In the basic sciences, the units of measure employed are almost universally the simple units of the international metric system—the meter and the gram—with their derivatives. In engineering and applied science, the units employed have gradually likewise become metric in all parts of the world except in the English-speaking countries, where both the time-honored but cumbersome English and American systems of units persist. Even in the English-speaking countries, however, a gradual transition may be perceived towards the ultimately inevitable international metric system. When the transition shall have become complete, the mutual advances in engineering and in science will be rendered more easy and rapid, through the use of the same language of units. This simplification will benefit science and engineering, not only in this country, but also in all parts of the world where records in our units may extend.

The advances of science and of engineering have thus far always enriched mankind materially. Material production has been greatly hastened; so that the average possessions of men have been increased, or else larger populations have been supported to divide the increase. It is doubtful, however, whether increase of human happiness, beyond a relatively small modicum of possessions, is at all commensurate either with the growth of material wealth or with the growth of population. It seems that while science can largely increase general comfort and prosperity, it can, at present, insure but little increase of happiness and contentment. Whether this must always and inevitably be so, is debatable, and depends to some extent on our definitions of science. In any case, we must turn for help to moral and spiritual sources of happiness, if we are to continue to become increasingly indebted for material wealth to the scientific revelations of the interpretable universe. At present, it appears that advancement in the power to enjoy and give contentment is more difficult for us collectively to acquire than advancement in the power to secure material benefit through science and engineering. In the discovery and maintenance of these uplifting philosophies, the calm and contemplative orient has surpassed the tense and restless occident.

It is generally admitted that the study, either of the sciences or their applications, tends to produce in the mind of the student a sense of humility and a respect for truth. Indeed, it is not strange that habits of

seeking or applying scientific truths should engender habits of faithful thinking. In this respect there is encouragement in the belief that the tendency of the present engineering age is, on the whole, towards accuracy of reasoning and precision of thought. Scientific ideas may tend slowly to dominate over irrational and irregular thinking. A casual review of general literature over long periods of time seems to show that as science has advanced irrational and superstitious ideas have dwindled. The concomitant danger, however, lies in the occasional ravages of erroneous pseudo-scientific doctrines. A plausible but false doctrine, that masquerades as a scientific proposition, may produce more harm in a scientifically disposed world than a flagrantly immoral popular belief of a clearly irrational character. The responsibility for making unguarded statements that are unsupported scientifically thus rests increasingly upon all speakers and writers.

In the development of the applied sciences, a constantly increasing demand devolves upon the underlying basic sciences. In the prehistoric times of primitive engineering only the simple rudiments of the underlying sciences may have been involved. In the ancient Egyptian and Roman days, engineering must have demanded a closer study of mathematics and physics for support. Since, however, the dawn of the present engineering age, much more knowledge and research have been demanded in a long list of the branches of basic science. Invention is always needed. But whereas in past times, inventors, if they had the requisite talents, did not need much scientific knowledge, at the present time, the successful inventor has not only to be endowed with inventive ability, but he must also be well versed in basic science. It appears that in the future this demand for basic scientific knowledge, as a prerequisite to applied-science progress, will continually increase.

The leadership of the ancient world rested mainly upon physical force. The trend of the more recent past through the present, towards the future, is for world leadership among the nations to rest mainly upon science and its applications. Already the progress of engineering is hampered and thwarted in many directions by lack of advance in the basic sciences. It is to these that national attention should be directed, for the progress of knowledge that benefits first the nation in which it is made, and later all the other nations. If only in the interests of applied science, the advancement of basic science in America should be stimulated and fostered. Support for applied science is likely to be forthcoming from the industries themselves; but support for basic science is more difficult to secure. The national importance of this is so great that the need should be made widely known. An effective way to stimulate advance in the science in this country would be to secure permanent endowment for a suitable annual prize, to the most notable contribution each year, in each section of the American Association for the Advancement of Science. This official recognition of scientific achievement would stimulate and encourage researches in all sections. There is no reason to fear that such scientific progress might be practically valueless. Useless scientific knowledge is now a contradiction in terms. Moreover, aside from the question of immediate versus future application, the patient earnest study of truth, in those parts of the universe that are attainable to us mortals, constitutes the noblest quest with which we are yet acquainted.

A. E. KENNELLY
HARVARD UNIVERSITY

SOME PSYCHOLOGICAL EXPERIMENTS[1]

II

THE age curve is of fundamental interest for psychology. Thus, for example, a child can learn to pronounce his own or a foreign language best at the age of about three years; there is then a drop and after about twelve years he can not learn correct enunciation. Perhaps a boy can learn to ride a bicycle best at the average age of ten, to drive a motor car at the age of sixteen. Our most original ideas probably come in the early twenties. Some of us may hope that the curve for forming correct judgments rises at least to the age of sixty-five. Our primary school system consists largely in trying to teach children, with much labor and resulting stupidity on the part of both teacher and pupils, mathematical relations a couple of years before the organism is ready and could respond to them without effort. Then, as this is the easiest subject in which to examine children, they are promoted from grade to grade mainly on performance in arithmetic without regard to individual differences in other kinds of work.

The Binet-Simon scale, first used in 1905 to diagnose subnormal children and in 1908 to measure the mental age of children, developed in this country by Dr. Goddard, Professor Yerkes, Professor Terman and many others, together with the group tests that we owe to Mr. Rice, Dr. Courtis, Professor Thorndike and many others, have been of untold value to our schools and to the children who are the ultimate

[1] Address of the retiring president of the American Association for the Advancement of Science, given at Kansas City on December 28, 1925.

origin and end of all our efforts. Even more important than the segregation of backward children is the giving of opportunity to children of promise and of genius, which should perhaps be the principal concern of a democracy. In describing experiments on this subject in 1896 I wrote: "We consequently need to study methods which will discover individual differences early in the life of the child. Education may properly be devoted to overcoming defects which would interfere with usefulness, but perhaps its most important function is to strengthen qualities which the individual possesses and which may be developed so as to serve his welfare and that of society. From the point of view of science, private benevolence and state aid should be directed less to supplying the cripples with crutches than to supplying the agile with ladders. For this purpose it is evidently important to devise tests which will demonstrate natural aptitudes while the child is very young."

The upper end of the age curve is of special interest to some of us. For example, we do not know at what age university professors should be retired from active service, but, if it is sixty-five, then it should be not the calendar but the physiological and psychological age of sixty-five. The average variation in mental age from the chronological age of children of ten is about one year, whereas after middle life it is much greater, increasing perhaps as the square root of the age. Some men at sixty-five are really younger than the average man of sixty and some older than the average man of seventy. Most people complain of their memory; they seldom admit that they have bad judgment. We can measure both and determine how an individual departs from the average and how this departure varies with age.

Learning and practice can be studied to special advantage with the lower animals. The fundamental work in Dr. Thorndike's Columbia dissertation of 1898, placing the study of animal behavior on an experimental basis, has developed into a branch of our science. Dr. Bagg, in his dissertation on individual differences and family resemblances in animal behavior, found that strains differed, but there was no measurable resemblance among young of the same parents. He found a lack of correlation in different kinds of performance, the difficulty appearing to be that our present maze and discrimination tests do not adequately measure variations of individual ability. Such experiments are in a class very different from the queer results recently announced by Professor Pavlov on the inheritance of the conditioned reflex.

There was published in 1890 in *Mind* an article entitled "Mental Tests and Measurements," and in 1896 in *The Psychological Review,* established in the meanwhile in cooperation with Professor Baldwin, an article entitled "Physical and Mental Measurements of the Students of Columbia University." This was the first series of tests used with a large number of individuals and it still remains the most extensive undertaking of this character. The students were tested at the beginning of the freshman and the end of the senior year, the women of Barnard College as well as the men of Columbia College.

About an hour was given to the examination of each student and some thirty measurements were made ranging from height, weight and lung capacity, through keenness of sight, discrimination of pitch and reaction time, to memory, imagery and association. In addition some forty records and observations were made, ranging from color of eyes and hair to an estimation of intelligence and straightforwardness. Further the student at home filled in a blank answering some eighty questions ranging from the ages, and, if deceased, cause of death of his grandparents, to what profession or business he proposed to follow and in what calling he would prefer to succeed if he had his choice. Other information was also available including class standing in different subjects, success in athletics and social interests. It is possible to follow the careers of alumni in after life and to measure their children when they in turn come to college at about the same age. In addition to the Columbia students these tests were made on members of the American Association for the Advancement of Science at three annual meetings, measurements having been obtained of men so distinguished as Simon Newcomb and William James. At the St. Louis Exposition of 1904 a laboratory was set up and tests were made by Professor Woodworth and Dr. Bruner, both on the visitors and on the racial groups that were represented.

In working over the tests, Dr. Wissler used for the first time in psychology the methods of correlation developed by Francis Galton and Professor Pearson. The correlations among the grades in different studies were significant and have been the basis of many subsequent studies. The lack of correlations among the measurements was at the time disappointing. It is due in part to the attenuation from measurements that are only accurate when deduced from averages, in part to a real lack of correlation in different traits. For example, a student who is accurate may be as likely to be quick or slow as one who is inaccurate. There is no correlation, but one fourth of all students will be above the median, one in a hundred in the first tenth, in both accuracy and quickness and will have a great advantage. The correlations—due to the circumstance that the same abilities and training are involved—discovered among complicated performances, such as class work and intelligence tests,

have led to their cultivation and to the neglect of the simpler measurements. The cultivation is desirable, the neglect unfortunate. It is of interest to any one to know where he stands among others in these traits and determinations; some of them, such as color blindness or acuity of hearing, which can be measured in a couple of minutes, may be of real use. It is also the scientific method to be followed in analyzing the more complicated processes, such as those going under a term so ambiguous as general intelligence.

Estimates of character and of other psychological traits are difficult and unreliable. No correlation has been found in the Columbia laboratory between size or shape of head and ability of any sort. There is no known relation between complexion, forehead, nose, chin, or other features and psychological traits. The reading of character by physiognomy or graphology is the occupation of charlatans. It is difficult or impossible to tell even the sex of the individual from the features of the face or from the handwriting. These are, of course, legitimate subjects of study. The full and side face have been photographed through a centimeter netting with a long focus lens, thus obtaining in a moment a large number of determinations, which are on the average as exact as can be got by direct measurement. The method can be used to advantage with children or savages, who do not like to be measured, and it is useful in recording and preserving a large number of determinations, some of which may prove to be of unexpected value. Photographs of the face were cut in parts to determine by what features we recognize the individual, and estimate the age, sex, etc. A study was also made in which individuals were judged first from a photograph, later after a five-minute interview, and then by individuals who knew them well.

It is possible to put judgments of character on a quantitative basis. In the earliest undertaking of this character five instructors in Columbia University were graded on a percentile scale by twelve fellow instructors and graduate students. Twenty-four traits or qualities were included, ranging from physical health to efficiency and leadership. There were used the psychological categories of intellect, emotion and will, together with the quantitative differences to which they have a certain analogy, breadth, intensity and quickness. All these qualities are useful, but it is especially desirable that a scientific man should have broad intellect, an artist intense emotions, a soldier or statesman quick will. We can fancy that these are unit characters which are combined by chance in Mendelian fashion. The probable error in position in a centile order for different traits estimated by twelve observers was only 4 places, ranging from 3 to 5.2, and apart from constant errors there is thus a close agreement. The chances, for example, are even that a man ranked 51 for integrity, with a probable error of 5, is more honest and straightforward than 45 of a hundred of all scientific men and less so than 44. A man ranked 95 for courage with a probable error of 3 is to the best of our knowledge more courageous than 9,400 of the 10,000 scientific men of the country, and the chances are even that this position is correct within 300 places. There was greater agreement on mental balance than on physical health; there was least agreement on cheerfulness, most on energy, perseverance and efficiency.

There is a certain amount of validity in judgments of personal traits, character and performance, and individual differences in the reliability of the judgments of those taking part in these experiments have been measured, showing a variation in competent observers covering a range of about two to one. It is an accepted truism that success in business and in other directions depends on the wise selection of associates and agents and on the ability to predict how others will act in given circumstances. When we learn to look upon our observations, recollections, beliefs and judgments objectively, stating in numbers the probability of their correctness, there will be an extraordinary change in our attitude in religion, politics, business and all the affairs of life.

In a study of examinations, grades and credits of the students of Columbia University it was proposed that grades be standardized on the basis of order of merit and the probability curve, that credit toward degrees be given for quality as well as for quantity of work, and that tuition fees be inversely proportional to quality. In a fivefold grading system, if half of the students are given the median grade of C, 22 per cent. B and D, 3 per cent. A and E, then the differences among the five groups are theoretically about equal; but 10 per cent. can be given honors and 10 per cent. failed if that is preferable. This plan has been largely adopted, and the grades given by different instructors become comparable and have some meaning. The giving of extra credits for good work was adopted at Columbia College in 1905 and has since been extended, though not to the extent that it should be.

Normal individuals tend to differ about as two to one, as has been indicated for a number of measurable traits. A good student can complete the work for the doctor's degree in two years about as well as a poor student can in four years. A good stenographer earns $40 a week while one who is inferior earns $20. Grades can be standardized and credits given on a scientific basis so that a student earns his degree in an equitable manner. Not only credits

should be given, but tuition fees should be charged in accordance with quality of work. Thus if the annual tuition is $300, the upper 10 per cent. of the students might pay $200, the lower 10 per cent. $400, others in proportion. Such a plan would be a proper use of trust funds given to defray the cost of college education, and would make scholarship and good work a reality.

In grading class work or in estimating character, the order of merit method should be used. A grade of 60 should not mean that a student has just passed or that he has done 60 per cent. of the work, but that among a hundred students in the same group there are about 40 better in their work, about 59 not so good. The order of merit method of converting a qualitative series into a series of quantitative differences had been used earlier in laboratory experiments. Some two hundred shades of gray were made, giving approximately equal differences in illumination between white and black. In such a series the grays toward the white end appear more alike than those toward the black end, and two adjacent grays are indistinguishable. Psychologically it is a qualitative series. If now the grays are arranged in the order of brightness a number of times by the same or different observers and the average position in the series of each gray is determined, the mean variation is inversely proportional to the psychological differences between the grays. There is thus determined the quantitative difference in the perception and its relation to the physical differences between the lights. The method can to advantage be applied to the determination of individual differences in the perception of the brightness of lights or in color blindness.

In the case of intensities or of qualities, the objective stimuli can be measured and the errors of the observers determined. The method of order of merit or relative position can, however, be used when the criterion is the agreement of different observers, as in the work already described on the determination of differences in character. It has been applied in the Columbia laboratory in various directions. Professor Thorndike has used it for handwriting and composition, and these scales have proved to be of great value in school work and have been developed in many directions.

Before the selection of a thousand students of Columbia University and a thousand American scientific men, a study was made of the thousand most eminent men of history and this was the basis for the later studies by order of merit. From each of six French, German, English and American biographical dictionaries or encyclopaedias were selected about 2,000 of those allowed the longest articles. From the some 6,000 individuals so determined were taken those who appeared in at least three dictionaries and from these were selected those given the greatest average space, the several dictionaries being reduced to a common standard. Thus was obtained not only the thousand men given most attention, but also the order in which they stand. The method further permitted the assignment of a probable error of position, which can be used as a measure of differences in eminence, and, if we assume the distribution of the probability curve, the differences between eminent men and average individuals.

Curves may be drawn showing the historical distribution of eminent men by nationality and by performance. After the Greco-Roman period and the so-called dark ages, there is a rise in numbers from the tenth century onwards, but with definite fluctuations in productivity. In the fifteenth century, Italy, England, France and Germany had nearly the same number of eminent men. Italy was in the lead, but then falls, as does Germany, while England and France rise, their curves crossing through the centuries with nearly an equal number of distinguished men, England surpassing in the number of highest eminence. France reaches its culmination at the end of the eighteenth century. Germany rises rapidly from the second half of the seventeenth century, and the American curve then begins with much promise for the future.

An analysis of the kind of performance shows that France has excelled in war, science and scholarship, England in politics, poetry and philosophy, Italy in art. Of the eighteen great musicians, Germany has produced ten, Italy six. Of the fourteen great explorers, England has produced five, Spain four. Though text-books and treatises on history, at least until the most recent period, are mainly concerned with wars and politics, there have been fewer eminent sovereigns, soldiers and statesmen than scientific men, philosophers, poets, artists and the like. The rising curves for science, the falling curves for philosophy and the church are significant. Soldiers have been surpassed in numbers by men of science and the curves predict a gradual cessation of war and the predominance of science. Similar curves have been made for the percentage of the total population of different countries engaged in war through the centuries and, though the data were inadequate, they also point to the gradual elimination of war. But of course the projection of curves is a scientific method that must be used with the utmost caution. By similar methods a list of 1,000 American scientific men who died prior to 1900 has been compiled and the changing interests can be shown by curves. A quantitative study of history is a possibility of the future.

Data have been collected concerning some of the 1,000 eminent men of history and a supplementary list of 10,000 has been used, with a view to placing

information in regard to them on a statistical and quantitative basis, determining how they differ among themselves and from others, and the conditions favorable to performance. Our present information is from anecdotes and examples from which almost anything can be deduced. We do not even know whether history depends on its great men or whether these are by-products of economic and other forces. We do not know the extent to which their performance depends on heredity and on opportunity.

The distinctions hold not only for men of eminence, but extend to differences adapting ordinary individuals to the work that they can do best. Thus three types of people, intergrading but often well defined, are those most satisfied and competent when dealing, respectively, with personal and emotional relations, whether the poet or the salesman; with material objects and definite situations, whether the military leader or the mechanic; and with abstractions, whether with the Deity or the atom or simply with words and figures. In the transportation services most of the employees have functions separated on the lines of these three types. The clerks, bookkeepers and stenographers are concerned with words and figures; the conductors and pursers must remember faces, be obliging, ready to answer questions, interested in the affairs of the passengers; these traits are disqualifications for motormen and engineers, who should be concerned about objects and machines. By a rough natural selection those tend to become clerks, conductors or engineers who are best suited for the work, but probably over ten per cent. of the employees could be transferred with an average increase of more than ten per cent. in their efficiency; new employees could from the start be assigned to work for which they are best fit. By the use of the psychological tests that we now have and by research to perfect these tests, the corporations concerned with transportation could effect a direct saving measured by tens of millions of dollars a year, indirectly of a comparable sum through the greater welfare and contentment of their employees.

In addition to the groups already noted a study has been made of American men of science, selected by the order of merit method. The sciences were divided into twelve groups and the number in each was taken approximately proportional to the total number of scientific workers, ranging from 175 chemists to 20 anthropologists. In each science the men were arranged in the order of the value of their work by ten leaders. The average positions and probable errors were then calculated, giving the order in each science. These were interpolated to give a list of about 2,000 names, but in the main only the first thousand have been considered. The list was obtained in 1903 and again in 1910. In 1920 it was compiled for the third time, but by a different method, used partly for its scientific interest, partly in order to avoid too great demands on the time of a few leading scientific men and to prevent any inbreeding from a limited number of judges.

The names and addresses of the scientific men included in each science in the two previous selections were sent to those on the list and they were asked to increase it by about 20 per cent. All those who received more than one vote were then asked to make nominations and those who received the most votes were added to the list up to a number of names twice as large as was to be selected. The names were then sent in alphabetical order to each of those included and he was asked to check about half the names to indicate those whose work he regarded as of most merit, with a double check for about one in twenty whose work he considered the most important. Some 2,000 scientific men were asked to take part in the selection and about 1,000 complied. The probable error of the position of the individuals was nearly the same as before. The measurement of the validity of a vote has application from the decision of a committee to a national election.

The scientific men are thus arranged in the order of the value of their work with a probable error which shows the correctness of the position assigned to each and also measures the differences between them. It consequently becomes possible to measure the scientific productivity of a region of the country or of an institution and its contemporary strength, with the changes that occur at different periods. The single figure giving the gain or loss in position of a scientific man in the course of ten years condenses a great deal of information and is dramatic in its implications. When we put knowledge concerning men of science on a statistical and quantitative basis, we may hope ultimately to determine the hereditary and environmental conditions favorable to the production and to the productivity of workers in science.

There are large variations in the origin and in the present residence of scientific men throughout the United States. Their birth rate per million population was 109 in Massachusetts and decreased from that center to 47 in New York, 23 in Pennsylvania, 9 in Virginia, less than 2 in the Gulf states. Their present residence tends to correspond with their place of birth, but some cities and states obtain more scientific men than they produce and conversely. Scientific activity is moving westward. Of younger men added to the list the birth rate fell in Massachusetts from 109 to 85, in New York from 47 to 36, whereas it increased in Michigan from 36 to 74, in Minnesota from 23 to 59.

In academic production and possession of scientific men Harvard leads by a wide margin, though the Johns Hopkins has given nearly twice as many doctorates to those who have attained scientific standing. In 1920 there were at Harvard 73 of our thousand leading scientific men. The numbers in other large institutions were—Columbia, 42; Chicago, 39; Yale, 35; Johns Hopkins, 35; Cornell, 33; California, 31. From 1905 to 1920 the net gain was at Yale, 9; at Harvard, 7; at the Johns Hopkins, 5; at California, 4. Chicago and Cornell were stationary; the net loss at Columbia was 18. The men can be weighted, in which case the relative strength of Harvard becomes greater. The ten strongest departments in each of the twelve sciences have been determined, Harvard among universities standing first in mathematics, physics, chemistry, botany, zoology, pathology and anthropology; second in geology and physiology. The Johns Hopkins had one of our leading thousand scientific men for 37 students. At Harvard the ratio was 1:75, at Yale, 1:105; at Columbia, 1:202. In the fifteen-year period the Department of Agriculture had a net loss of 9, the Geological Survey of 6; the Smithsonian Institution of 5; the Bureau of Standards a gain of 11. The Carnegie Institution and the Rockefeller Institute had large gains as had also the industrial laboratories. The movement of scientific men to the research foundations and laboratories is one of the notable changes of the past twenty-five years.

The list of a thousand scientific men permits not only the measurement of scientific merit and a study of the origin and distribution of scientific workers, but offers opportunity for obtaining vital and other statistics. Thus, to take an example, the average size of the completed family of the scientific men is 2.2. Voluntary control increased from 48 per cent. of marriages prior to 1880 to 70 per cent. of those contracted in the nineties. Childlessness was involuntary in two thirds of the cases; the standardized two-child family was desired in six cases out of seven. Or again, the brother of a scientific man is two hundred times as likely as another to be himself a scientific man.

We need scientific knowledge concerning scientific men and the conditions favorable to scientific work and to the scientific career. In the course of the week during which these remarks are being written, Secretary Hoover in an address to the Society of Mechanical Engineers has stated that the United States is behind most European nations in scientific research, and President Butler in his annual report has stated that Columbia University can not replace "older scholars of distinction and large achievements," because "a choice must be made from a larger or smaller group of mediocrities." It may be that we are inferior to other nations and that we now produce fewer scientific men of distinction than formerly, but both statements are open to question. The circumstance that they are made by men of wide information and can be neither proved nor disproved shows the urgent need of correct information.

It is the business of psychology to secure such knowledge, to determine how those fit for scientific research can be selected, what training should be given to them, what positions, opportunities and rewards are most effective. Scientific men should apply scientific methods to their own work and to securing the widest cooperation. Books and journals, including technical publications for scientific men, others that will interest the "average man" in science and in the wider application of the scientific method, are leading agencies. Science Service, for which this association shares the responsibility, should be made a large factor in the dissemination of science. But of all agencies for the promotion and diffusion of science, scientific societies are the most important—the national societies in each science, the state and local academies, most of all the association in which these are united and which at its annual meetings and at all times advances the interests of science and of scientific men and impresses on the widest public the weight and magnitude of modern science. We owe homage and service to the American Association for the Advancement of Science.

The experiments used in this address as illustrations of work in psychology may seem like an autobiographical obituary notice. It might have been better to have taken as a subject the contributions of our great leader, William James, or those of his contemporary, Stanley Hall, whom we have more recently lost. There are now five or six hundred active psychologists in the United States; their work is bewildering in extent, offering innumerable subjects for discussion. It is, however, easier and more human to play the part of little Jack Horner, and it is perhaps more in accord with the method of science to bear witness to direct experience. The Spanish dramatist pessimistically claims that man's greatest crime is having been born. For an optimist the greatest misfortune is to have been born a long time ago. But in the case of a psychologist there is compensation in the circumstance that he has thus been able to witness and to share the history of his science from the beginning.

Psychology, like the other sciences, may date back to Aristotle and as much further as records go; but the earliest research laboratory of psychology was established by Wilhelm Wundt at Leipzig in 1879. The first laboratory courses for students were con-

ducted by me in 1887 and 1888 at the University of Cambridge, the University of Pennsylvania and Bryn Mawr College. When in 1881 and later I worked with Wundt, who was professor of philosophy and lectured over a wide range of philosophical disciplines, he held that the object of psychological experiment was to improve the conditions of introspection and that only the psychologist could be a subject in the laboratory. Early experiments led me to adopt the points of view that psychology, on the one side, is concerned with conduct as well as with consciousness, behavior being the more open to experimental investigations and their useful applications; on the other side, that individual differences are of primary importance, both for constructive science and in the practical affairs of daily life.

There are able psychologists who like to narrate what they think they think, what they feel they feel, what they imagine they imagine. Those of us who are concerned with quantitative measurements and objective results wish them satisfaction, even though we may think, feel or imagine that such literary diversions contribute about as much to a science of psychology as similar stories about their rheumatism and other bodily ailments would contribute to a science of pathology. Some good souls may derive comfort from arguing that they are or have good souls. With Browning's Cleon each might like to say:

> And I have written three books on the soul,
> Proving absurd all written hitherto,
> And putting us to ignorance again.

Philosophy may offer God, freedom and immortality, and it may make some difference whether it does or does not. But the shades of metaphysics wander about the Elysian fields in those obscure regions beyond the river Styx to which the light of science does not reach. Hamlet said: "There are more things in heaven and earth than are dreamt of in our philosophy." There are certainly more things dreamt of in philosophy and in some kinds of psychology than are in the heavens above, or in the earth beneath, or in the waters under the earth; but they do not give us a science of psychology.

In spite of the limited value for science of direct introspection, our mental life is part of the real world, and is that part which is of the greatest concern to each of us. It may be, as has been suggested, that psychology lost its soul long ago and is now losing its mind; but it can not lose consciousness. Our perceptions, thoughts, intentions and feelings are not only elements in sensori-motor arcs; for us they are the end to which the whole creation moves. As far as production goes, consciousness may be only a spectator; but it is the ultimate consumer. We shall have in due time a scientific psychology of human welfare, of the things that are beautiful, good and true. But it will not come until we get these things instead of talking about them; for science has meaning and value only in its usefulness. Psychology may supply economic values equal to those of the physical and biological sciences, human values of even greater significance.

Scientific research and the applications of science in the course of 150 years have increased fourfold the productivity of labor; they have doubled the length of life. Science has made it possible for each to work at routine tasks half as long as formerly and at the same time to consume twice as much wealth as formerly. Fourteen hours of labor, shared by women and children, once provided hovels, lice and black bread for most people, luxury for a few. Seven hours of labor will now supply comfortable homes, warm clothes and healthful food for all. If the resources provided by science were properly distributed—as they will be when we have an applied science of psychology—there is now sufficient wealth to enable all to share in the desirable luxuries that science has created, and to enjoy in full measure the most nearly ultimate goods of life—home, friends, things to do, freedom, self-respect.

The better lives secured through the increased wealth provided by science, together with the applications of science to hygiene, medicine and surgery, have doubled the length of life. In the nations of the west pestilence and famine have lost most of their terrors; of the three evil fates only war survives from a prescientific and barbarous past. Much is crude and ugly in the modern world; atrophied instincts and aborted impulses must be replaced by the products of a science of psychology before living can become free and fine. But those who call our industrial civilization materialistic and ignoble have narrow thoughts and scant idealism. They fail to imagine what it means in terms of love and suffering that of ten infants born, formerly only two or three survived childhood, while now eight or nine may live to have children of their own.

The applications of science have abolished slavery and serfdom, the need of child labor, the subjection of woman; they have made possible universal education, democracy and equality of opportunity, and have given us so much of these as we have. Science has not only created our civilization; it has given to it the finest art and the truest faith. The advancement of science should be the chief concern of a nation that would conserve and increase the welfare of its people.

J. MCKEEN CATTELL

A SUGGESTED COURSE OF STUDY FOR MEDICAL TECHNICIANS

THE proper training of those who desire to fit themselves for various professional vocations is an ever-present problem, involving serious responsibility for those engaged in educational work. To this end institutions of learning are reaching out toward newer methods of teaching. The rapidly changing conditions in vocational fields are being recognized and with this recognition there is or should be a distinct and apparent necessity for thoughtful planning in order to direct those who desire to take up the various lines of vocational and professional work into their most logical channel of livelihood. Educational institutions are finding it necessary to provide instruction in new lines of endeavor and to arrange courses which will meet more recent economic developments.

To be specific, during the last several years there has been a constantly increasing demand for laboratory technicians in public health institutions and in the laboratories of specialists in medicine. Several factors have contributed toward this condition. The work of our army and navy during the World War required special training of the members of the Medical Reserve Corps. At the base hospitals, both at home and abroad, clinical laboratory examinations were continually recognized as having a very decided weight. So much so that the many thousands of medical men who were useful in service during the war returned to private practice and found themselves more dependent upon accurate laboratory diagnosis than ever before. Another important factor which has very greatly stimulated the demand for properly trained technical workers in laboratory medicine is the dependence placed upon the rating which is given to hospitals by the American College of Surgeons. Thus, in order to become recognized as class "A" institutions, hospitals must maintain clinical laboratory departments representing personnel trained in this line of work. Furthermore, it is becoming universally recognized not only by medical men but, due to popular educational methods, by the lay-public as well, that clinical laboratory tests are necessary for a safe and sound diagnosis.

At the present time practically every member of a community has access to clinical laboratory diagnosis and he is to a greater or less extent dependent upon these laboratories. To illustrate: there are few well-treated cases of typhoid fever, pulmonary tuberculosis, diabetes mellitus, blood diseases or cardiovascular-renal diseases which do not have, through the aid of the physician, the benefit of laboratory procedures, both in diagnosis and in treatment. Thus, in typhoid fever, blood cultures are made early in the course of the disease for diagnosis, later followed by agglutination tests. Blood examinations are frequently conducted not only as an aid in diagnosis but as an indication of the progress of the disease. The diagnosis and treatment of diabetes is dependent upon carefully conducted laboratory work. A really thorough study of any patient suffering from diabetes or cardiovascular-renal diseases calls for a comparatively extensive laboratory examination, involving studies of the urine and blood and a measure of basal metabolism.

All this means that the medical profession, and the public as well, are beginning to realize the great responsibility which rests upon the clinical pathologist and his corps of technicians. In carrying out work of this nature, literature must be consulted, experience and training must be called into action and good judgment must be exercised at all times. It is demanded that the physician's clinical diagnosis should be based upon thorough scientific observation resting upon a background of accurate laboratory data and a thorough knowledge of scientific medicine.

Realizing, therefore, that in many cases a portion of the data upon which the doctor depends for his diagnosis is furnished by the laboratory, it is vitally important to demand a most thorough training as well as conscientious work on the part of the laboratory technician. As Kolmer[1] and MacEachern[2] have recently pointed out, clinical pathologists and many physicians will admit that it is not an uncommon occurrence to find many so-called medical technicians scattered over the country, even in good laboratories, who exemplify lack of skill, scanty knowledge and gross inexperience. Such a condition of affairs should not exist. Indeed, they can not last for long if we judge the present trend of thought in our medical schools.

One reason for all this lies in the fact that the demand for well-trained laboratory technicians has increased at such a rapid rate that it has not been possible to fill the vacancies. Hence, it has seemed necessary to draw upon all types of available help. The laboratory technician is desired by physicians and surgeons in private practice, by groups of physicians, by large clinics, hospital laboratories, state and municipal institutions, private clinical laboratories and state and city boards of health.

The demand for this class of scientific help, being so wide, it is imperative that we give very serious

1 "Education as a cure for present-day evils in clinical pathology," *Journal of Laboratory and Clinical Medicine*, X, August, 1925, page 891.

2 "The rôle of the clinical pathologist in hospital efficiency," *Journal of Laboratory and Clinical Medicine*, X, August, 1925, page 898.

thought to some immediate means of correcting this condition. It is only fair to the community at large, the medical profession and the individual patient that the scientific group, commonly designated as laboratory technician, be organized upon a more definite and thorough plane.

Among the methods which have been followed in attempting to train medical technicians, individual training has been by far the most widely practiced. This has resulted in an entire absence of standardization of training. An individual who has had no high-school work and who has been located for a week or two in some laboratory may be rated as a medical technician. On the other hand, an equally poor worker may be found who possesses a bachelor's degree. Grant and Wilson[3] state that within a year they had occasion to employ at least thirty technicians, all of whom had had various opportunities for experience and training. Some had bachelor's degrees, some had M.D. degrees, but not two per cent. of this number, according to the authors, could do efficient work. This is the usual experience of the majority of laboratory directors, and the condition will not improve until proper courses of study are provided for those who desire to take up medical technology and laboratory medicine.

It is suggested, therefore, that educational institutions should give serious thought to provision for the adequate preparation of those who desire to become trained laboratory workers. The bachelor's degree in general science does not suffice, even though the course includes chemistry, physics, biology, bacteriology and other sciences directly concerned with laboratory medicine. Such courses, together with certain cultural courses, offer the proper background but do not furnish the technical training which is necessary. The work which medical technologists pursue is at least as exacting and as highly professional in nature as that of the registered pharmacist or the registered nurse. The medical technician needs a strictly professional course, involving not only knowledge of the subjects related to the work, but also a clear viewpoint of medical technology as a profession. The student should secure a broad foundation, learn well the many different methods of technique, become proficient in scrutinizing newer developments, understand the interpretation of laboratory findings and learn to appreciate the problems of the clinician. Adequate preparation for this work involves strictly professional scientific training.

At the last meeting of the American Society of Clinical Pathologists a course of training for medical technicians was submitted by the writer. It was stated that the ideal course for medical technicians should consist of four years of study leading to the degree of B.S. in medical technology. Experience has shown that such a course can not be secured advantageously by selecting subjects here and there from different departments of the university or medical school. This course should be strictly technical, in which a large portion of the work is that specifically involved in medical technology. The course which was submitted could be undertaken without difficulty at any well-organized educational institution. Thereby a distinct service to the medical profession and to humanity would be performed. It was suggested that in undertaking such a project the initial step should be the institution of a vocational course. Such a course was first suggested in a paper read in 1922[4] and was applied by the writer in a practical manner for a period of three years.

In the beginning, this course might consist of one year, thirty-six weeks of didactic training followed by sixteen weeks of apprenticeship or practical training in an accredited hospital or public health laboratory. Such a course might be arranged as follows:

Subject[5]	Lecture hours	Laboratory hours	Laboratory periods (4 hours)
Clinical bacteriology	48	136	34
Clinical analytical methods	48	120	30
Hematology	30	120	30
Serology and immunology	34	148	37
Blood chemistry	20	40	10
Urinalysis	30	80	20
Parasitology	15	8	2
Tissue technique	5	40	10
Functional and sensitization tests	3	28	7
Anatomy and physiology	40	----	----
Medical terminology	40	----	----
Interpretation of findings	10	----	----
Autopsy demonstrations	10	----	----
Special lectures	27	----	----
Total	360	720	180
Apprenticeship (16 weeks, 8 hours per day)		704	
Total		1,424	

By the beginning of the second year the course of

[3] *Journal of Laboratory and Clinical Medicine*, June, 1922, page 562.

[4] King, "The Training of the Laboratory Technician," *Minnesota Medicine*, April, 1923, page 233.

[5] Space does not permit description of the subjects. It may be assumed, however, that all routine laboratory diagnostic procedures are included under the various subjects listed. For instance, the complete examination of spinal fluid is included under "Clinical analytical methods," "Serology," "Hematology" and "Special lectures."

instruction for vocational students should be increased to full two years, consisting of two periods of thirty-six weeks of didactic training and two periods of sixteen weeks each of apprenticeship or practical training in an accredited hospital or public health laboratory. The subjects offered in such a course and suggested balancing of subjects might be as follows:

Subject	Lecture hours	Laboratory hours	Laboratory periods
Clinical bacteriology	72	200	50
Clinical analytical methods	72	200	50
Hematology	48	180	45
Serology and immunology	60	220	55
Blood chemistry	32	80	20
Urinalysis	32	88	22
Parasitology	20	20	5
Tissue technique	18	80	20
Functional tests	10	20	5
Anatomy and physiology	72	8	2
Sensitization tests	6	4	1
Roentgen ray	120	240	60
Basal metabolism	26	100	25
Medical terminology	72	—	—
Interpretation of findings	10	—	—
Autopsy demonstrations	10	—	—
Special lectures	40	—	—
Total	720	1,440	360
Apprenticeship (32 weeks, 8 hours per day)		1,408	
Total		2,848	

At the beginning of the project, provision should be made for a course leading to the degree of B.S. in medical technology. It should consist of the two-year technical course preceded by two years of college work. The college work should consist of the accepted pre-medic courses, of sixty semester credits including: English, six credits; chemistry, thirteen credits; physics, eight credits; biology, six credits; and French or German, six credits. Subjects suggested or advised are Latin, English, mathematics, psychology, sociology, physiology, comparative anatomy and drawing.

Every leading medical institution maintaining extensive laboratory facilities is besieged by those who desire to secure training in medical technology, but at the present time those who desire to enter this line of work seek almost in vain for any recognized courses of training. Hundreds of students drop out of our universities annually, not so much because of failure, but rather because of lack of objective.

It would seem, therefore, that present conditions warrant and demand that well-recognized educational institutions take the initial step toward carrying out a project of this nature. Surely, a distinct opportunity is presented.

WALTER E. KING

DETROIT, MICHIGAN

SCIENTIFIC EVENTS

PRESENTATION OF THE ROYAL SOCIETY MEDALS

As already noted in SCIENCE, the Royal Society medals were presented at the anniversary meeting on November 30, by the retiring president, Sir Charles Sherrington. The following citations, in addition to that with the Copley medal to Professor Einstein (SCIENCE, January 1), were made with the award of the medals:

A ROYAL MEDAL: PROFESSOR WILLIAM HENRY PERKIN

The science of organic chemistry owes a debt to Professor Perkin, as instanced in recent years by his monograph on cryptopine and protopine, a record of chemical research rarely equalled in experimental skill and precise reasoning. He has revealed the constitutions of the alkaloids harmine and harmaline; he is nearing the solution of the structures of strychnine and brucine, two alkaloids which have hitherto resisted all attempts to determine their structural formulae. His work on berberine has left few questions unanswered concerning the constitution of this important substance. He has developed new methods of attack on the chemistry of these natural products, and has faced many problems in structural organic chemistry. He succeeded, during a period of twenty years at the University of Manchester, in building up there a notable school of chemical research. During the past twelve years, in the University of Oxford, he has again organized and developed a similar research school.

A ROYAL MEDAL: PROFESSOR ALBERT CHARLES SEWARD

Professor Seward's work has been conspicuous on account of the way in which he has extended and reduced to order our knowledge of the paleobotany of Gondwanaland, especially in India, South and Central Africa, Antarctica and the Falkland Islands. The lower stages of the Gondwana system are characterized by evidences of a glacial climate; and in order more completely to understand the conditions of life that existed, Professor Seward has visited Greenland and otherwise paid special attention to the effect of climate and light in explaining the rise and luxuriance of the Glossopteris flora in the Southern Hemisphere. In addition to its direct stratigraphical value to geologists, his work has added greatly to our knowledge of plant migration, and especially of the way in which the Glossopteris flora invaded the Northern Hemisphere previously occupied by the groups familiar to us by our Coal Measure plants.

THE DAVY MEDAL: SIR JAMES IRVINE

The constitution of the simpler sugars (monosaccharoses) was based on a sure foundation by the classical

researches of Emil Fischer. Taking up the investigation where Fischer had left it, Sir James has carried the inquiry into the more complex field of the disaccharoses, and by means of new processes, which he has been able to evolve and apply, to assign definite chemical structures to many of these most important natural products. He has also studied the constitutions of the still more complex polysaccharoses, starch and inulin, incidentally gaining an insight into the manner in which the plant forms and utilizes these fundamental reserve materials.

THE SYLVESTER MEDAL: PROFESSOR A. N. WHITEHEAD

Always primarily interested in the foundations of mathematics, it is in the logical analysis of these foundations that Professor Whitehead's reputation has been won. The great work, "Principia Mathematica," written in collaboration with Bertrand Russell, contains the most systematic and the most profound analysis to which the foundations of the subject have yet been submitted.

From pure mathematics both Professor Whitehead and his collaborator have turned independently to physics. In his more recent books Whitehead has endeavored to apply the spirit of "Principia Mathematica," and in particular the principle which he calls "extensive abstraction," in the more complicated and more controversial field of physical existence. That a point, whether in the older physics or the modern physics of space-time, is a class, or a class of classes, of events, that an electron is a systematic correlation of the characters of all events throughout all nature, are doctrines at which the unsophisticated may be tempted to scoff, but the tendency of modern scientific thought is to the conclusion that, if the world of physics is indeed ultimately capable of any rational interpretation, it must be interpreted in some such way.

THE HUGHES MEDAL: MR. F. E. SMITH

Mr. Smith began work on the realization of the fundamental units of electrical measurement in 1902; and such further experiments as have been made since have served only to confirm his results. Other important investigations by Mr. Smith have dealt with the measurement of terrestrial magnetism. The recording magnetometers which he designed have proved of great value, while more recently he constructed, at the suggestion of Sir Arthur Schuster, a horizontal force magnetometer of extreme accuracy. During the war his services to the nation were of great importance, and since the armistice, as director of research at the Admiralty, he has been responsible for a number of valuable investigations.

THE NEW MUSEUM OF NATURAL HISTORY AT YALE UNIVERSITY

THE new Gothic Building for the Peabody Museum of Natural History at Yale University was formally dedicated on December 29 with ceremonies attended by many scientific organizations, including the Geological Society, the Society of American Naturalists and the American Association of Museums. President Angell delivered an address of welcome to the delegates on behalf of the university. Dr. Henry Fairfield Osborn, of the American Museum of Natural History, spoke on the development of paleontology, especially in its relation to biology, and Dr. Schuchert, emeritus professor of paleontology and secretary of the museum trustees, spoke on the historical aspect of the building and institution. Professor Edward Salisbury Dana, president of the board of trustees, formally presented the museum to the university and Professor Lull, director of the museum, explained the layout of the building.

This towered brown structure, fronting Whitney Avenue and occupying the southeast corner of the Pierson-Sage Square, with spacious lawns about it, replaces the historic Peabody Museum at High and Elm Streets, which was demolished in 1917 to make room for the Memorial Quadrangle. The collections, which have been in storage since then, are completely reinstalled, and the museum is now ready to resume its full activity.

The building is entirely of concrete, brick, steel and glass. All the stone is artificial. There are ten halls on two exhibition floors. The second, or mezzanine floor, contains offices, laboratories, library, seminar rooms, etc. The basement is given over to storage, except for the space under the tower, called the crypt, which contains the seismograph. This is one of the three seismograph stations in New England.

Externally, the building is Gothic. That style of architecture was chosen because it admits of irregularity, and from time to time new wings will have to be added to the present structure. One, already planned, will contain an auditorium. The museum has no debts, and is in a favorable position for growth and expansion, should the needs and opportunities of the future make such growth desirable.

PUBLIC LECTURES ON SCIENTIFIC AND MEDICAL SUBJECTS

A COURSE of free public lectures will be given in the educational building of the New York State Museum on Friday afternoons at four o'clock, as listed below. The lectures are on subjects of general and popular interest and will be untechnical. Many of them will be illustrated by lantern views.

January 8.—*Social Life among Insects:* EPHRAIM P. FELT, state entomologist.

January 15.—*Geologic History of the Hudson River:* RUDOLF RUEDEMANN, assistant state paleontologist.

January 22.—*Forest Trees:* HOMER D. HOUSE, state botanist.

January 29.—*Making and Maintaining a Port of Albany:* JOHN H. COOK, superintendent of John Boyd Thacher Park.

February 5.—*Adventures with Wild Birds and Animals:* HOWARD H. CLEAVES.

February 19.—*The Use of Plants in Medicine:* WILLIAM MANSFIELD, dean of the Albany College of Pharmacy.

February 26.—*A Tour of New York State Parks:* C. A. HARTNAGEL, assistant state geologist.

March 5.—*Forest Protection and Reforestation:* WILLIAM G. HOWARD, state conservation commission.

March 12.—*Experiences with Snakes:* SHERMAN C. BISHOP, zoologist.

March 19.—*Geologic Factors Governing the Growth of the City of Albany:* JOHN H. COOK, superintendent, John Boyd Thacher Park.

March 26.—*New York Archeology:* NOAH T. CLARKE, archeologist.

April 2.—*Wild Flowers:* HOMER D. HOUSE, state botanist.

The sixth annual course of public Sunday afternoon lectures, offered by the zoological museum of the University of Minnesota, will be given as indicated on the following program. The lectures will be given as heretofore in the general lecture room on the third floor of the animal biology building at 3:30 every Sunday afternoon during January, February and March, and will be illustrated by lantern slides. One or more reels of motion pictures will be shown each afternoon either in connection with the lecture or immediately following in the same room.

January 3.—*Our Birds and Their Insect Food:* THOS. S. ROBERTS, director of the zoological museum, University of Minnesota.

January 10.—*Nature Study in Our Public Schools:* MISS JENNIE HALL, supervisor of nature study in the Minneapolis public schools.

January 17.—*Evidences of Prehistoric Man in Europe; a Recent Survey:* A. E. JENKS, professor and chairman of the department of anthropology, University of Minnesota.

January 24.—*The Wild Life of Isle Royal:* FRANK M. WARREN, of Minneapolis.

January 31.—*Bacteriophages and Their Relation to Disease Germs:* ROBERT G. GREEN, assistant professor of bacteriology, University of Minnesota.

February 7.—*An Illustrated Talk on Minnesota Reptiles:* MRS. GRACE WILEY, curator of the museum of the Minnesota Academy of Sciences, Minneapolis.

February 14.—*How Forests Feed the Clouds:* RAPHAEL ZON, director, Lake States Forest Experiment Station, U. S. Department of Agriculture.

February 21.—*The History and Habits of the Termites or White Ants:* DWIGHT E. MINNICH, associate professor of animal biology, University of Minnesota.

February 28.—*Water Babies:* CHARLES P. SIGERFOOS, professor of zoology, University of Minnesota.

March 7.—*Eight Days on the Desert:* WILLIAM S. COOPER, assistant professor of botany, University of Minnesota.

March 14.—*Origin of Minnesota Plant Life:* C. O. ROSENDAHL, professor of botany, University of Minnesota.

March 21.—*The Native Orchids of Minnesota:* N. L. HUFF, assistant professor of botany, University of Minnesota.

March 28—*Rambles of a Bird Lover in Minnesota:* THOS. S. ROBERTS, director of the zoological museum, University of Minnesota.

The faculty of medicine of Harvard University offers a course of free public lectures on medical subjects to be given at the Medical School, Boston, on Sunday afternoons, beginning January 3 and ending March 21. The lectures will begin at four o'clock and the doors will be closed at five minutes past the hour. The speakers and subjects are as follows:

January 3.—*America's Problems concerning Tropical and Exotic Diseases:* DR. RICHARD P. STRONG, professor of tropical medicine, Harvard University.

January 10.—*The Effect of Sunlight on Growth and Development:* DR. WILLIAM T. BOVIE, assistant professor of bio-physics, Harvard University.

January 17.—*The Work of the Food and Drug Division of the Massachusetts Department of Public Health:* HERMANN C. LYTHGOE, director of the food and drug division, Massachusetts State Board of Health.

January 24.—*Gonorrhea and its Complications* (to men only): DR. GEORGE G. SMITH, instructor in genito-urinary surgery, Harvard University.

January 31.—*Cancer and New Growths:* DR. S. BURT WOLBACH, Shattuck professor of pathological anatomy, Harvard University.

February 7.—*Certain Aspects of the Diseases of the Organs of Respiration:* DR. FREDERICK T. LORD, instructor in medicine, Harvard University.

February 14.—*Some Observations on the Progress of Public Health in China:* DR. REGINALD M. ATWATER, instructor in epidemiology, Harvard University.

February 21.—*The Use and Misuse of the X-Ray:* DR. MERRILL C. SOSMAN, instructor in Roentgenology, Harvard University.

February 28.—*Modes of Infection:* DR. WILLIAM L. AYCOCK, associate in preventive medicine and hygiene, Harvard University.

March 7.—*How One May Conserve Eyesight after Mid-Life:* DR. J. HERBERT WAITE, assistant in ophthalmology, Harvard University.

March 14.—*Prenatal Care* (to women only): DR. FREDERICK C. IRVING, assistant professor of obstetrics, Harvard University.

March 21.—*Health Service—the Aim of Modern Dentistry:* DR. LEROY M. S. MINER, professor of clinical oral surgery and dean of the Dental School, Harvard University.

OFFICERS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

AT the Kansas City meeting of the American Association for the Advancement of Science, officers were elected as follows:

President

Liberty Hyde Bailey, Cornell University.

Vice-presidents

A.—E. V. Huntington, Harvard University.
B.—W. Duane, Harvard University.
C.—Lauder W. Jones, Princeton University.
D.—R. G. Aitken, Lick Observatory.
E.—Eugene A. Smith, University of Alabama.
F.—Winterton C. Curtis, University of Missouri.
G.—B. M. Duggar, Missouri Botanical Garden.
H.—R. Bennett Bean, University of Virginia.
I.—Margaret Floy Washburn, Vassar College.
K.—Dr. I. P. Willits, University of Pennsylvania.
L.—W. Carl Rufus, University of Michigan.
M.—C. R. Richards, Lehigh University.
N.—Rufus Cole, Rockefeller Institute for Medical Research.
O.—C. F. Marbut, U. S. Department of Agriculture.
Q.—M. E. Haggerty, University of Minnesota.

Member of the Finance Committee

A. S. Frissell, The Fifth Avenue Bank, New York, N. Y.

Trustee of Science Service

J. McKeen Cattell.

Members of the Executive Committee

M. I. Pupin, Columbia University, New York, N. Y.
F. R. Moulton, University of Chicago.

Members of the Council

Rodney H. True, University of Pennsylvania.
John C. Merriam, Carnegie Institution of Washington.

Members of the Grants Committee

Vernon Kellogg, National Research Council.
L. G. Hoxton, University of Virginia.

SCIENTIFIC NOTES AND NEWS

THE meeting of the American Association for the Advancement of Science and associated societies held at Kansas City, Mo., from December 28 to January 2, with a registration of about 1,900, was notable both for its scientific programs and for the addresses presented at the general sessions. A full report of the meeting, prepared by the permanent secretary, will be contained in a special number of SCIENCE to be issued on January 29.

THE third annual thousand dollar prize of the American Association for the Advancement of Science has been awarded to Dr. Dayton C. Miller, professor of physics at the Case School of Applied Science, for his address on "The Michelson-Morley Ether Drift Experiment," being the presidential address before the American Physical Society, presented at a joint meeting with the American Association, Kansas City, on December 29.

DR. LIBERTY HYDE BAILEY, elected president of the American Association for the Advancement of Science at the Kansas City meeting, was also elected president of the Botanical Society of America.

DR. HARVEY CARR, professor of psychology in the University of Chicago, was elected president of the American Psychological Association at the recent meeting held at Ithaca, N. Y.

DR. JOSEPH ERLANGER, professor of physiology in the medical school of Washington University, has been elected president of the American Physiological Society and Dr. Alexander Forbes, associate professor of physiology in the Harvard Medical School, treasurer. Dr. Walter J. Meek, professor of physiology in the University of Wisconsin, was reelected secretary.

WILLIAM L. ABBOTT, chief engineer of the Chicago Edison Company, was elected president of the American Society of Mechanical Engineers at the recent meeting in New York City.

THE next Lane medical lecturer at Stanford University will be Dr. R. Magnus, professor of pharmacology at the University of Utrecht, Holland, who will probably deliver his lectures in December, 1927.

PROFESSOR MARSTON T. BOGERT, of the department of chemistry at Columbia University, has been elected chairman of the section of chemistry of the National Academy of Sciences for the period 1926–29 in succession to Professor Wilder D. Bancroft, of Cornell University.

DR. EDWARD C. ROSENOW, of the Mayo Clinic, Rochester, has been awarded the Callahan gold medal for 1925 by the Ohio State Dental Society for "outstanding contributions to medical, bacteriologic and dental education."

JOHN I. CRABTREE, head of the photographic department of the Kodak Research Laboratories, and Merle L. Dundon, one of his associates, have been awarded bronze medals by the French Photographic Society, in recognition of their work on the determination of the kinds of fog produced on sensitive photographic material.

THE prize of the Marcel Benoist endowment, Zurich, has been awarded this year to Professor H. Zangger, director of the medicolegal institute, Zurich, for his recently published work on "Poisonings."

DR. LOUIS JACQUES SIMON, professor of organic chemistry at the Museum of Natural History, Paris, has been made an officer of the Legion of Honor by the French government.

R. B. MITCHELL, the Glasgow city electrical engi-

neer, has been invited, as president of the I. M. E. A., to attend a conference of the International Electrotechnical Commission in New York next April, and the electricity committee has recommended that this visit be authorized by the city council and that Mr. Mitchell's expenses be defrayed.

DR. PAUL B. DUNBAR, of Maryland, has been appointed as an additional assistant chief of the Bureau of Chemistry of the U. S. Department of Agriculture. Dr. Dunbar will have general supervision of administrative matters relating to the enforcement of the federal food and drugs act, the tea inspection act and the naval stores act.

RAY V. MURPHY, formerly instructor in physical chemistry at the Carnegie Institute of Technology, Pittsburgh, has resigned to take a position with the Western Electric Company, Chicago, as a member of the staff of the Switchboard Lamp Laboratory.

DR. S. C. HARLAND, professor of botany at the Imperial College of Tropical Agriculture, Trinidad, has arrived in London from a trip to Panama, California, Honolulu, Japan, the Philippine Islands, Malay, Burma and Ceylon, where he has been investigating the possibilities of finding banana plants immune to Panama disease and limes not susceptible to withertip.

PROFESSOR ALDO CASTELLANI, of the London School of Tropical Medicine, arrived in New York on December 31, *en route* to New Orleans to take up his duties as professor and head of the department of tropical diseases at the Tulane University of Louisiana School of Medicine.

DR. SIDNEY F. BLAKE, of the United States Bureau of Plant Industry, returned in November from abroad, where he had been examining types of South American compositae at the principal European herbaria.

DR. ALBERT P. MATHEWS, professor of biochemistry at the University of Cincinnati College of Medicine, is in England on sabbatical leave, working with Professor Edward C. Baly, of the department of physical chemistry, and with Professor Ramsden, of the department of physiology at the University of Liverpool.

DR. WILLIAM T. BOVIE, assistant professor of biophysics at Harvard University, will give a series of eight lectures under the auspices of the Lowell Institute during the month of January in Huntington Hall, Boston, on "The Influence of Light on Living Organisms."

DR. JOHN C. MERRIAM, president of the Carnegie Institution of Washington, will give a lecture before the Columbia University Chapter of Sigma Xi, on January 14, at 8:15 in Schermerhorn Hall. His subject will be "Cave Exploration in California and its Bearing upon Problems of Pleistocene History."

DR. GEORGE E. VINCENT, president of the Rockefeller Foundation, New York, will deliver an address at the celebration of the fiftieth anniversary of the Boston Medical Library, on January 19.

PROFESSOR CHAS. H. RICHARDSON, professor of mineralogy at Syracuse University, gave a lecture at the Missouri School of Mines on December 18 on the subject of "Science and Religion."

DR. HOMER L. DODGE, of the University of Oklahoma, retiring president of the Oklahoma Academy of Science, gave an address on "Research as a State Policy" at the annual dinner of the academy on November 27.

PROFESSOR WILLIAM OTIS CROSBY, professor emeritus of geology at the Massachusetts Institute of Technology, died on December 31, aged seventy-six years.

PROFESSOR ALBERT CHAUNCEY EYCLESHYMER, professor of anatomy and dean of the college of medicine at the University of Illinois, died from a bullet wound on December 30. Dr. Eycleshymer was fifty-eight years of age.

DR. WILLIAM S. FOSTER, professor of psychology at the University of Minnesota, died on January 2, aged thirty-seven years.

FILIBERT ROTH, emeritus professor of forestry at the University of Michigan, died on December 4 at the age of sixty-seven years.

DR. JOHAN AUGUST BRINELL, Bessemer medallist in 1907 of the Iron and Steel Institute, whose name is associated with the hardness testing of materials, died on November 17, aged seventy-six years.

PROFESSOR JOSEPH BROUGH, formerly professor of mental and moral science at the University College of Wales, died on December 7, aged seventy-three years.

SIR JERVOISE A. BAINES, an authority on Indian ethnography, died recently at the age of seventy-nine years.

DR. ERNST H. EHLERS, professor of zoology in the University of Göttingen, died on January 2 at the age of ninety years.

THE committee on scientific research of the American Medical Association invites applications for grants in aid of research on problems of interest to clinical medicine. Applications should reach the committee before February 15, 1926, and may be addressed to 535 N. Dearborn St., Chicago.

THE Japanese Association for the Advancement of Science was formed in April, 1925. The first annual meeting was held from October 30 to November 2 in Tokyo under the presidency of Dr. Kozai, president of Tokyo Imperial University. The next meeting will be in Kyoto.

A SERIES of radio talks on "Chemistry and Human Progress" will be broadcast Wednesday evenings at 8:15 P. M. (Eastern standard time) from the University of Pittsburgh studio of the Westinghouse Station KDKA as follows: January 6, "Chemistry Advancing Civilization," Alexander Silverman; January 13, "Maintaining a Safe Milk Supply," Chas. Glenn King; January 20, "From Atmosphere to Soil," Kendall S. Tesh; January 27, "Dyes as a Civilizing Factor," Alexander Lowy; February 3, "Explosives and Human Progress," Gebhard Stegeman; February 10, "Speeding up that Process," Carl J. Engelder; February 17, "Where will Chemistry lead us?" Alexander Silverman.

THE following papers were read before the Astronomy and Physics Club of Pasadena during the fall: "An Application of the Quantum Theory to the Emission of Light by Diffuse Nebulae," Dr. H. Zanstra; "The Gravitational Displacement of the Lines in the Spectrum of the Companion of Sirius," Dr. W. S. Adams; "Report on the Southampton Meeting of the British Association," Dr. H. Bateman; "Metastable Helium," Dr. C. Eckart; "Penetrating Radiation," R. A. Millikan and G. H. Cameron; "Slow Electrons in Gases," Dr. F. Zwicky; "Coronal Radiation," Dr. Edison Pettit; "A New Mass Spectrograph," Dr. W. R. Smythe; "Conduction and Evaporation Losses from Lakes," I. S. Bowen and N. W. Cummings; "Astronomical Evidence on Gravitational Displacement of Spectral Lines," Dr. C. E. St. John.

PROFESSOR DAVID EUGENE SMITH, of the department of mathematics at Teachers College, Columbia University, exhibited his collection of documents and objects relating to the history of mathematics at the meeting of the American Mathematical Society, which opened in New York City on January 1. There are 40,000 rare books, manuscripts, letters, portraits and instruments in the collection. Dr. Smith explained his collection at the afternoon session and told of receiving Omar's book from a Persian of Northern India. It is said to be the only copy remaining in a private collection. The text is in the Persian writing of the poet-scientist. Another interesting work in the collection is one of the two copies in the United States of the book of Al-Khowarizim, a Persian, who used the word algebra for the first time. There are also 3,000 portraits of mathematicians, said to be the largest number in one collection.

EMIL KAEMPFER, accompanied by his wife, sailed this week for Para, Brazil, where they will start on an expedition into the coastal regions to collect seabirds and other forms of life and then proceed to the remote sections of the country to collect specimens of bird and animal life for the American Museum of Natural History. From the seacoast Mr. and Mrs. Kaempfer will travel by mule pack train to Nova York on the Parnahyba River, a district which has not been entered by collectors for fifteen years. Their final explorations will be made in the State of Bahia.

IT is reported that the Detroit Arctic expedition will leave Detroit on January 20, for Point Barrow, Alaska. From there the explorers will make an attempt to reach the north pole by airplane, taking off about March 21. Captain George H. Wilkins, leader of the expedition, and Dr. Vilhjalmur Stefansson, Arctic explorer, were in Detroit on January 2, to attend a dinner given in their honor by the Detroit Aviation Society.

A MUSEUM of natural history with branches of art, zoology and botany has been established at Roanoke, called the Virginia Museum of Natural History, Inc. The incorporators are M. A. Johnson, *president;* W. Ryland Martin, *secretary;* T. M. Nunn and E. A. Buchanan, all of Roanoke.

THE *Journal* of the American Medical Association states that at the instance of Dr. Tsuji, of the Kyoto Imperial University College of Medicine, Japan, a Society of Endocrinology was organized for the first time in Japan. The society placed a journal in circulation as its organ, of which the first number was issued recently. It will hereafter be issued every other month.

STANFORD UNIVERSITY has received a donation of $4,000 from Mr. Roy N. Bishop, of San Francisco, in support of research work on diseases of the kidneys that is being carried on by Dr. T. Addis, and $5,000 from Mrs. Dorothy Fries Lilienthal, to establish a scholarship in memory of her mother, Florence Hecht Fries, to be known as the "Florence Hecht Fries Scholarship in Medicine."

DR. WILLIAM GATES, director of the department of middle American research at Tulane University, has given to the university $50,000 to be used in the furtherance of Central American research, not alone from an archeological standpoint, but relative to the study and development of tropical botany, agronomy, forestry, climatology and tropical medicine. It is hoped that further sums may be contributed towards the fund. An official invitation has been extended the department of middle American research of the university by the government of the Republic of Guatemala to establish an agricultural research station in Guatemala and to cooperate with that country in the development of its resources by an exchange of exports between New Orleans and the Central American country.

UNIVERSITY AND EDUCATIONAL NOTES

YALE UNIVERSITY will receive $600,000 and the Sheffield Scientific School $300,000 under the will of George St. John Sheffield, of Providence.

A GIFT of $250,000 for the erection of a medical clinic building at the University of Pennsylvania has been made by Martin Maloney, of Philadelphia.

BOWDOIN COLLEGE receives $250,000 by the will of the late Frank A. Munsey, of New York.

CORNELL UNIVERSITY has received a gift of $50,000 from the Robert Boyd Ward Fund, Inc., of New York City. Income from the gift is to be available to the president for meeting emergency needs not provided for in the university's annual budget, such as the purchase of scientific apparatus or supplies, publication of the results of research in the university and lectures in the advancement of science.

THE Massachusetts Institute of Technology will receive $25,000 for "its general uses and purposes" under the will of Kenneth F. Wood.

A NEW course surveying the whole field of science has been organized at the University of New Hampshire by the cooperation of nine departments, representing all the natural sciences and mathematics, and will be offered to freshmen beginning with the winter term. The aims of the course are to give the freshmen a unified view of the whole field of science, showing the interrelations of the several physical sciences, to survey briefly each main division, and to familiarize students with scientific methods.

THE teaching in public health and preventive medicine at Stanford University has been completely reorganized and Professor E. C. Dickson, of the department of medicine, has been placed in charge as acting executive.

FRANCIS L. WHITNEY has been made professor of geology and paleontology at the University of Texas, having been promoted from the rank of associate professor.

DR. WILLIAM E. BROWN has been appointed assistant professor of preventive medicine at the University of Cincinnati College of Medicine.

A. M. ALVARADO, formerly professor of chemistry at the Waukon Junior College, Waukon, Iowa, has been appointed associate professor of chemistry at Loyola University, New Orleans, La.

DR. EDWARD TAYLOR JONES, professor of physics in the University College of North Wales, has been appointed to the chair of natural philosophy at the University of Glasgow, in succession to Professor Andrew Gray.

AT the University of Liverpool, Dr. T. P. Hilditch has been appointed to the Campbell Brown chair of industrial chemistry and Professor S. H. Gager, of the University of Edinburgh, has been appointed to the William Prescott chair of the care of animals with special reference to the causation and prevention of disease.

DISCUSSION AND CORRESPONDENCE

MILLIKAN RAYS AND THE ACCELERATION OF RADIOACTIVE CHANGE

SOME weeks ago (*Nature*, September 12, 1925), A. Gaschler reported that he had succeeded in accelerating the change of uranium to uranium X by submitting uranium oxide to "strong rushes of momentary high-tension currents." One may suppose that, in any group of uranium atoms, the nuclei of a certain number reach a state of unstability in each unit of time, and that these decompose. But, at the same time, other nuclei may closely approach the verge of unstability, and these also may be caused to decompose under the influence of a sufficient disturbing force from outside. For this reason, the idea of artificial transmutation of uranium is usually entertained more favorably than that of the transmutation of mercury to gold; although, it may be added, mercury atoms, while never crossing the verge of unstability of themselves, may, in like manner to uranium atoms, closely approach it. In either case, the force from outside must apparently be greater than such as would operate a hair trigger effect. The trigger has a heavy pull, and the conservative objectors to the reported mercury transmutation have pointed out that the intensity of the energy applied falls far short of that associated with changes in the nucleus.

Such a defect in intensity can not, however, be charged against Millikan rays as described in SCIENCE for November 20. The energy associated, for example, with alpha particles ejected from the nuclei of the radioactive elements may conveniently be stated as lying between four and nine million equivalent volts. This is exceeded many fold by the energy corresponding, on the quantum theory, to radiation of the high frequency of the Millikan rays. One is therefore reminded of the experiments of A. Nodon (*Compt. rend.*, 176, 1705 (1923)) who brought forward evidence of an increase of the activity of radioactive substances when outdoors and enclosed by envelopes of small absorbing power for gamma rays as contrasted to the smaller radioactivity of the same

substances in cellars and when heavily enveloped by lead. Nodon, it is true, attributed his "ultraradiation," as he called it, to the sun; but he reports some effect even at night (which he is at pains to interpret), as one would anticipate from the results of Millikan.

It may be recalled that rock analysis shows that, assuming percentage composition similar to that on the surface, there is enough radioactive material in a depth of only twelve miles of the earth's crust to supply by its daily disintegration all the heat the earth radiates daily into space. If atoms of number above eighty-two exist beneath this twelve-mile shell, and if they are distintegrating as actively as at the surface, we are forced to the logical conclusions of Joly, who supposes that the heat of radioactive origin will accumulate until the earth's hot interior, after a process of eversion, will disburden itself of its store of heat by radiation into space during one of the earth's "incandescent periods," and thus make ready for a fresh geological aeon. Such catastrophic events are, however, no longer inevitable if we alter one of the premises in the logic, and grant that the radioactivity of the heavy chemical atoms is not entirely spontaneous but is conditioned, in part at least, by irradiation by Millikan rays, which would penetrate only a limited distance into the earth's crust. One must suppose that workers in laboratories are so well and so constantly screened that fluctuation in rate of radioactive change has escaped them.

However this may be, further experiments on the possible acceleration of radioactive change by these very high frequency radiations would appear to be of great interest, and we hope Professor Millikan is planning such experiments.

ALAN W. C. MENZIES
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INSECT TOXICOLOGY

THERE is a growing tendency to supplement field experiments on insecticides with tests and comparisons in the laboratory where, under controlled conditions, more exact observations and deductions may be made. This development in economic entomology is exemplified particularly by the work of Moore, Richardson, McIndoo and Tattersfield. The writer believes that laboratory research on the effects of insecticides would develop more rapidly and fruitfully if laboratory and field workers alike had a single, definite conception of its purpose and potential importance.

The purpose of laboratory research on the poisoning of insects has been obscured in part by the lack of a significant name for it. At times it has been classed under insect physiology; again it has been allied with chemical field control work in economic entomology. The writer proposes for it the name, *insect toxicology*,[1] to include the results of all investigations which deal in a quantitative manner with the effects of insecticides on insects. The term, insect toxicology, is not entirely free from ambiguity, because it also suggests the effects of poisons elaborated by the insects themselves; but, with the foregoing definition, it should be satisfactory.

Insect toxicology should have for its purpose the development of a body of knowledge comparable to vertebrate toxicology or pharmacology. Just as in medicine, pharmacology supplies a rational, scientific basis for applied therapeutics, so in entomology, insect toxicology should be expected to supply a similar sound basis for insecticide practice. The need for an insect toxicology fashioned in the manner of pharmacology has been recognized, consciously or unconsciously, by workers with insecticides who turn to manuals of pharmacology for suggestions, although they know that the vertebrate toxicology of such manuals may not be applicable to insects, even in a qualitative sense. The quantitative conception of insect toxicology is especially important. Innumerable insecticide "cage experiments" have been carried out by many workers. The results have been more or less useful at the time and place of completion, but because they were not obtained under carefully controlled conditions by quantitative methods they have no value for building up the fundamental laws of insect toxicology which could be applied to the analysis of insecticide poisoning under any combination of natural conditions.

The writer has been devoting his time and thought to insect toxicology for several years, and has become convinced that it is practicable to build up a quantitative system of insect toxicology both for stomach-poison and contact insecticides on a few suitable laboratory insects. This conviction, for stomach-poisons at least, will be supported by subsequent publication of methods and results, which the writer believes compare favorably with those of vertebrate toxicology.

If the objection be made that the analogy between insect toxicology and pharmacology is not sufficient proof for the potential importance of the former, instances may be cited of the practical results already secured through insect toxicology. The impulse for the development of coated arsenicals for the Japanese beetle sprang from William Moore's observations on the repellant effect on the beetle of sublethal doses of

[1] This term does not conflict with *economic toxicology* proposed by M. R. Miller (SCIENCE, XLIV, p. 264) to include all aspects of work in which poisons are employed to economic advantage.

arsenic. Price showed quantitatively that honey-bees are quite susceptible to arsenic poisoning, and, therefore, it would be unwise to run the risk of killing bees by spraying trees in blossom. Richardson has done promising quantitative work on nicotine substitutes. The writer will offer quantitative proof for conclusions on some practical matters in arsenical practice. He intends to show that acquired individual tolerance to arsenic is very unlikely; that, on a unit weight of larva basis, young larvae are less resistant to arsenic poisoning than older larvae; that different species of insects may vary decidedly in resistance to equal doses of arsenic on a unit weight of insect basis, and that trivalent arsenic is more toxic than pentavalent arsenic.

In general, insect toxicology may be expected to analyze the complications of insecticide practice, and so help to explain failures and suggest improvements in field materials and methods. However, immediate practical results should neither be desired nor expected from every investigation in insect toxicology, since the more fundamental branches of science have invariably profited by an unlimited range of inquiry.

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THE REQUIREMENT OF MATHEMATICS FOR COLLEGE FRESHMEN

NEXT to freshman "English," a year of mathematics is doubtless the most universal requirement in our colleges. Such preeminence requires unusual justification. Broadly speaking, mathematics serves two purposes: it is a tool for the solution of certain immediate problems, and it is an instrument for thought. Too few students ever attain the perfection of skill in technical manipulations to enable them to use mathematics in solving real—as contrasted with classroom—problems. If we are to justify requiring mathematics of every one or virtually every one, we must turn to the second purpose.

Mathematics is still justified as a formal discipline. It is considered to be fine training in accurate thinking. But the doctrine of formal discipline has undergone a good deal of modification under the buffeting of experimental study. We know, for instance, that no amount of purely formal or repetitive drill in accuracy will increase one's accuracy in general. To base the requirement of mathematics upon purely formal discipline is to play into the hands of the enemy.

Yet mathematics can be made a real training for thought. Clear, accurate and rapid thought depends largely upon the mastery of certain concepts, many or most of which are essentially mathematical in nature. To name but a few, how can one think clearly about certain problems without a grasp of the concepts of asymptotic approach to a limit, of maxima and minima, of independent and dependent variability and of functional relationship? Certainly one can attain to practical mastery of these concepts in circumscribed fields without the mathematical approach, but the surest route is surely through mathematics.

Is this to emphasize the obvious? Certainly, for mathematicians. But not for students. Mathematics has not succeeded in justifying itself to the student on these grounds.

More important, the point, however obvious, does not seem to have influenced the teaching of early courses in mathematics, either in secondary school or college. It is sound pedagogical principle to isolate for emphasis those factors in a study which are of greatest importance and which should form part of the permanent equipment of the student. Thus when the concept of functional relationship has been taught by means of specific instances, of problems to be solved according to a mathematical technique, the student should be led to *generalize* this concept as much as possible. Otherwise there is the gravest risk —rather the positive certainty—that it will remain a mere technical device for solving certain equations in "Math I." Yet how often is the notion of functional relationship correlated with Mill's so-called canons of induction in such a way that the student may see that this thing with which he has been dealing by means of abstract symbols is basic to all thought about cause and effect?

I therefore venture to suggest that an effort be made to list the fundamental concepts of mathematics which form the basis of clear, factual thinking. And that teachers of mathematics bend every effort to get the student to grasp the *universal* significance and applicability of these concepts. I can not believe that required mathematics will lose in popularity for this; nor does it seem that it will lose in effectiveness even in the teaching of technical manipulations. In any case, those who need the latter—engineers and physicists and so on—not less than others need to know the fundamental significance of their tools.

I am more uncertain about the second suggestion I have to offer. Great progress has been made in recent years in including certain statistical notions in freshman courses, but these courses are still oriented primarily towards mechanics. Now great as have been and probably will be the contributions of physical science to civilization, it has become a commonplace that the future of mankind for the next two or three centuries will depend less upon the con-

tributions of physical science than upon the machinery for their social control. That is, our future depends upon the extent to which in psychology and the social sciences fact is substituted for opinion and the insight of genius or expert. And fact in these fields means statistics. Fortunately the mathematical demands of statistical fundamentals is not so severe as would be inferred from the rather horrendous formulae.

We shall be told, of course, that the time is already taken up with absolute essentials; it always is in every course. But if the foregoing analysis is correct, these "essentials" are less important than some aspects now slighted. One realizes, of course, that the concepts for which we ask more attention are difficult to teach to students without knowledge of rudimentary mathematical operations. Drill in manipulations is essential; but how much? What I am pleading for is a slight shift in orientation. Once the objective is clearly defined, we are ready for a fresh attack on the problem of the irreducible minimum of drill in the manipulation of symbols. We are ready, also, on the side of content, to face the question whether it is more important to teach the student the sort of operations necessary to solve problems in mechanics and thermodynamics, which only a few of them will ever attempt to do, or the sort of operations necessary to solve the problems of citizenship, which ought to be the concern of all.

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SCIENTIFIC BOOKS

The Old Americans. By A. HRDLIČKA. Baltimore, Williams and Wilkins Company, 1925.

THE able curator of physical anthropology of the National Museum has for many years been making measurements and observations on the physical traits of men, women and children who are descendants through a number of generations on both sides of the early immigrants to this country. These early immigrants were less varied than those of the last few decades, being chiefly from the British Isles, with some admixture of Spanish, Dutch and Swedes and later some Germans. The elements were varied enough, however, to comprise, on the one hand, the tall, long-headed, light-pigmented northerners and the stocky, round-headed, deeply-pigmented peoples of the south of Europe. The immigrants were selected for sturdiness and energy. They came to a new country where conditions permitted of rapid spread, and healthy living, including abundant nutrition. The people of different European nationalities here intermarried and from this blend has gradually arisen a new type which Hrdlička calls the "Old American." To define this type it has been necessary to make extensive measurements for comparison with the natives of the different countries of Europe.

In his study Dr. Hrdlička examined over 900 subjects in detail and 1,000 additional, more superficially as to pigmentation, etc. The material is homogeneous in that old persons and children are not considered and the majority is drawn from the social middle class, excluding laborers or servants. A great many clerks and professional people are included. In the book there is first considered the pigmentation of the old Americans, including the color of the skin, hair and eyes. Under measurements are included tables and distribution curves on stature, weight, sitting height, chest, arms, hand, leg, foot, head and facial features. Physiological observations on pulse, respiration, temperature and muscular strength are considered. Finally the results of the study are given in a series of abstracts and a picture is drawn of the future American type. In the last chapter the reassuring conclusion is drawn that the new American "will in all probability be, in the average, tall, more sanguine, and perhaps less spare than the old. It will remain an intermediary white type in pigmentation, head form and other respects. It will show for a long time a wide range of individual variation in all respects. And it may well be expected to be a wholesome and effective type, for mixtures such as those from which it shall have resulted are, so far as scientific research shows, not harmful but rather beneficial, and conditions of life as well as environment in this country are still propitious."

The method of treatment of the subject matter makes this book more than a study of a group of persons. It is, on the one hand, a sort of text-book of anthropometry; on the other, it gives a comparative view of physical traits throughout the world while it lays especial stress upon the condition of the adult in the United States as a whole and in the separate sections of the country. For example, under "arms" we have a statement concerning the significance of this measurement, a description of the different methods of measuring arm length, a table of frequencies of the different absolute measurements of arm length in males and in females, together with frequency polygons of these results. There is a comparison of the youngest and oldest of the group in respect to arm length, a consideration of arm length in relation to stature and in relation to type of head. There is a table, two pages long, giving relative span in various groups of mankind for both sexes and, finally, there is a summary of the results, as far as old Americans go, with a brief comparison of the

arms of old Americans with those of other peoples. In some other sections as, for example, in that dealing with the head, averages and distributions are afforded not only for the whole data but for different states and comparative frequency polygons for different sections are given. Thus the work becomes a valuable hand-book of comparative anthropology of all races and pedigrees of different sections of the United States.

Of the care with which Dr. Hrdlička has worked there can be no doubt, as his technique is known to be excellent. A slight difficulty is introduced in the very nature of his subjects which has made it necessary to take the measurements over clothing, although shoes and outer clothing were dispensed with. Some allowance is made for the increase of measurements due to clothing so that weights, for example, are reduced to nude values. Hrdlička regrets that these are so difficult to compare with extensive series of measurements which have been made, for example, by life insurance companies, because of the varied amount of clothing in which people are measured, amounting in some cases to 8 per cent. of the total weight. Apparently the chest measurements are generally made by Hrdlička over the clothing; but girths are less used by him than breadth and depth, which are less modified by the ever troublesome clothing factor. The presence of clothes results in the measurements not being exactly comparable with those taken on young men at demobilization, the methods of taking which Dr. Hrdlička again criticizes, yet those measurements must remain for a long time the best collection of measurements of young males which has been made in this country, if not in the world, because of the fact that many of the dimensions taken were such as could be satisfactorily secured only from unclothed persons.

The book is illustrated by a large number of satisfactorily reproduced full-page plates of typical old Americans. The numerous frequency polygons are also drawn on a large scale so as to be readily interpreted. It is regrettable, however, that the marginal numbers, indicating the different classes, were drawn with a fine pen and sometimes much reduced in reproduction so that in some cases they are not very legible. In his table the author gives the number of individuals which were used in each class. He relies a great deal upon the average, but fails to give standard deviations or probable errors. In the absence of such standard deviations the tables of averages are less useful for comparison than they would otherwise be. The tables are inferior in this respect to those of Boas and Wissler, in which standard deviations were conscientiously worked out. A series of averages is of relatively little significance for comparison unless we have some idea of the relation between differences and probable errors.

The publishers have prepared an attractive book, both in paper, binding and printing. The whole work constitutes an important addition to the series of anthropological works which are appearing from American authors in ever increasing numbers. It is to be hoped that the interesting mixture of races which is occurring on the American continent will be made the object of further studies in the future and all such will find it necessary to refer to the data in the "Old Americans" as a basis for comparison.

CHAS. B. DAVENPORT

The Physics of the Developed Photographic Image: Monograph No. 5 on the Theory of Photography from the Research Laboratory of the Eastman Kodak Company. By F. E. Ross. Pp. 217. D. Van Nostrand Co., 1924.

EITHER a human eye or a photographic surface forms the receiving end of nearly every optical instrument. Each responds in characteristic fashion to the intensity and quality of the light operative. Each possesses its own limitations in sharpness and fineness of detail that may be rendered. Dr. Ross's monograph deals largely with these limitations in the case of the photographic negative. Ultimate causes are considered, carefully planned and very laborious investigations are described and the results analyzed and formulated.

Grain size, form and distribution are carefully considered in two chapters, together with the factors affecting them. The scattered and somewhat conflicting data of the reciprocity law are digested and a modified law formulated. Data and theory bearing on sharpness and resolving power, largely the work of the Eastman Laboratory, are most excellent. The chapter on astronomical photographic photometry will go far toward clearing up the confusion previously existing in that field. The two final chapters on the mutual action of adjacent images and on accuracy of photographic registration of position are models of exposition of exhaustive research by a master hand. An excellent bibliography and index are added.

This monograph is the first of its kind in this field. Along with the solid meat of fact and formulation some readers will wish there had been incorporated more general discussion for the sake of orientation and more speculation as to the ultimate causes as a stimulus to the imagination. The material presented is of the class that will appeal to the technical photographer and investigator rather than to the mere taker

of pictures. To the astronomer, the photographic surveyor and to those engaged in photographic research it will be invaluable.

P. G. NUTTING

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A DILATOMETER FOR MEASURING THE HYDRATION OF COLLOIDS

THE hydration of colloids is an important phenomenon in many physiological processes, as well as in many non-living colloidal reactions. Thus it is of interest to be able to measure the rate and amount of hydration and possibly, in some instances, to estimate the forces involved in the process. The swelling of the colloidal material usually occurs to a measurable extent as a result of hydration. The increase in size has long been used as a measure of the extent of hydration. Other methods which have been used with more or less accuracy are by (1) direct measurement of the pressure necessary to prevent swelling; (2) measurement of the heat of hydration; (3) measuring the rate of increase in weight of the material during hydration; (4) determining the increase of the specific gravity of the material; (5) determining the change in the freezing point of a solution of known concentration in which the material is immersed, and (6) determining the change of the specific gravity of a known solution of alcohol or salt in water in which the material is immersed. All these methods, however, are limited in their application or subject to large experimental errors, which can not be measured. Some colloidal substances do not swell equally in all dimensions, thus, any linear measurement is not an accurate measure of the extent of hydration. It is also known that the rate of hydration varies inversely to the degree of saturation, thus the total amount of hydration largely depends upon the degree of dryness of the colloidal material. An apparent increase in volume may also be brought about by an increase in dispersion, disintegration of the colloidal aggregates, which is often accompanied by a decrease in degree of hydration[1] as, for example, when a gelatin hydrogel changes to a hydrosol, or solid starch grains form a hydrosol when heated. A portion of the water held by a colloidal substance may be held by surface tension and thus not be water of hydration.

Hydration is regarded as a physical, chemical or physico-chemical union of water with many colloidal and non-colloidal substances. In any case, there is either a physical or a chemical condensation of the water; as in cases where there appears to be a purely physical relation the water is held in a highly compressed condition on the surface of the colloidal particle by the force of attraction between the two substances, or hydration is a phenomenon of solid solution; or there may be evidence of a chemical change, the water being held in a weak chemical union by the molecules of the substance.[2] If the colloid is a protein, some believe that the ions of the protein molecules are the units which are hydrated.[3] Thus a condensation or decrease in the volume of the water during the process of hydration furnishes an accurate measure of the rate and extent of the hydration. The volume of condensation of water at saturation in cubic millimeters per gram of dry material is here termed the "hydration factor" which is characteristic of the material under the conditions of the determination.

Some fraction of the water absorbed is held in a non-condensed condition and is not to be considered as a part of the water of hydration. This fraction varies with the conditions and the kind of material used. It is often impossible to measure the absolute amounts of water of hydration and water held in a non-condensed condition, but for comparative purposes the relative amounts of each are represented by the ratio of the hydration factor to the total amount of water absorbed per gram of dry material. This relation is termed the "hydration ratio." Thus the hydration ratio indicates the relation between the amount of water of hydration and the amount of the more mobile supply of water held in a non-condensed condition. It is probable that the water of hydration has the more important function in physiological processes and the water held in a non-condensed condition is utilized in hydration as these processes continue.

With some substances, as starch, for example, the absolute amount of water held in a non-condensed condition may be measured by the increase in weight of the dry material after it has attained equilibrium with air saturated with water vapor. In such cases, from the amount of water of hydration per gram of dry material and the hydration factor, the decrease in volume of a unit volume of water is easily calculated. The pressure necessary to cause an equal decrease in volume of pure water may be determined by referring to tables of the volume of water at dif-

[1] Fischer, Martin, and Coffman, W. D., *Jour. Am. Chem. Soc.*, 40: 304, 1918; Fischer, Martin, "Soaps and Proteins," New York, pp. 219, 1921.

[2] Loeb, J., "Proteins and the Theory of Colloidal Behavior," pp. 194, 1922.

[3] Jones, H. C., *Am. Chem. Jour.*, 34: 291, 1905.

ferent temperatures and pressures[4] and possibly is equal to the force of hydration. This is based on the assumption that the decrease in volume of the water results on account of the force of attraction between the water and the material.

Figure 1 is a diagram of the apparatus which has been used in this laboratory and has proved particularly interesting as an experiment to demonstrate the condensation of water in the process of hydration. To measure the rate of hydration of a colloidal substance the bottle is filled about two thirds full of dry mercury. A small amount of the material, which has been thoroughly dried, is placed on the surface of the mercury. The rubber washer is placed on the rim of the neck of the bottle. The hard rubber stopper which supports the nickel disc and capillary tube is then inserted in the neck of the bottle and the material is pushed under the surface of the mercury below the disc. The bottle is then immersed in water. When it is entirely filled, including no bubbles, the stopper is pressed tightly down upon the rubber washer. The lid is then slipped over the upper end of the capillary tube, the clamp placed with its two ends under the collar which surrounds the neck of the bottle. The apparatus is made water-tight by tightening the screw which at the same time raises the surface of the water in the tube. The apparatus is then placed in an accurately controlled thermostat until a constant temperature is attained. The water level in the tube is adjusted to the zero mark at the top of the tube by tightening the screw. The apparatus is then tilted until the dry material slips from under the nickel disc and rises to the surface of the mercury, coming in contact with the water without any change in the total volume of material in the bottle. As hydration proceeds the surface of the water in the tube lowers until saturation is reached, which requires varying lengths of time depending upon conditions and material used. If the material is non-porous, the decrease in the volume of water is on account of the condensation accompanying hydration. If the material is porous and some air is present with the colloid a small bubble may be displaced and rise to the surface of the water in the bottle. In this case a small error is unavoidable, owing to the slight change in pressure on the gas. However, the air may be removed by suction through the capillary tube by means of a vacuum pump. Number 13 of Figure 1 represents an improved disc which allows the material to be displaced from under the disc with only a slight tilt of the apparatus. The disc, 13, rotates clockwise on the axis, 14. As the apparatus is tilted clockwise the disc will turn up owing to the pressure of the mercury, thus allowing the material to rise readily into the water.

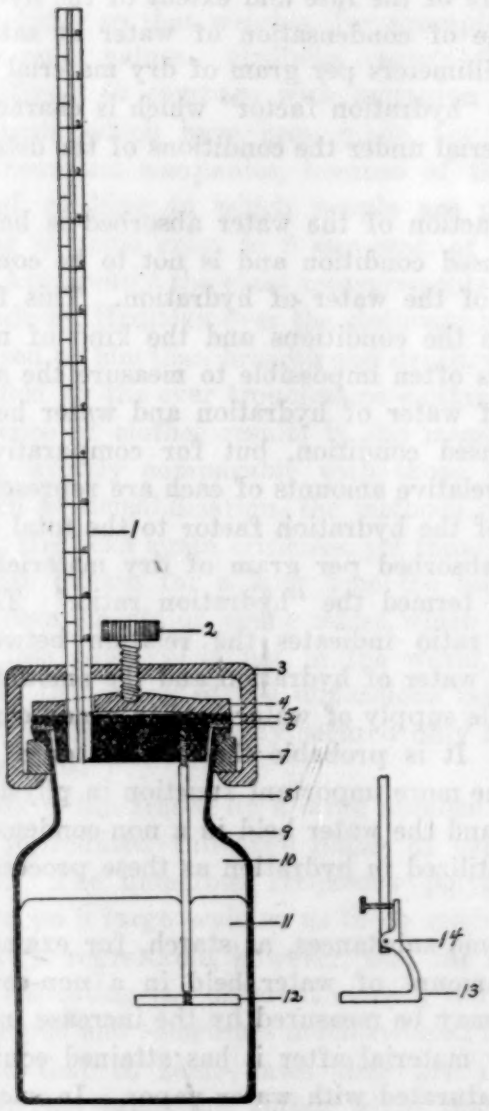

FIGURE 1

1. Calibrated capillary tube. 2. Brass screw. 3. Brass clamp. 4. Brass lid. 5. Hard rubber stopper. 6. Rubber washer. 7. Brass collar. 8. Nickel wire. 9. Wide mouth bottle of about 100 cc. capacity. 10. Water. 11. Mercury. 12. Nickel disc. 13. Improved nickel disc.

The method above described is particularly suitable for studying the effects of substances in solution upon hydration. When the material is a powder, such as starch, it is necessary to place it in a shallow capsule having one side open. Such capsules are easily made by dipping the end of a glass rod in collodion. After the ether has evaporated, dip the end of the rod in water before the collodion has entirely hardened. The collodion capsule can then be slipped off from the rod and dried. When thoroughly dry they imbibe very little water. The capillary tube can be accurately calibrated with a bead of mercury and fractional parts of the graduations are accurately made with an eye-piece micrometer in a horizontal

[4] Bridgman, P. W., Proc. Amer. Acad. Art. Sci., XLVIII, pp. 338, Sept., 1912.

microscope. For laboratory experiments where a high degree of accuracy is not essential the tube is graduated in millimeters, the variations in the cross-section of the capillary usually being very small. The volume of the capillary per centimeter is determined with a mercury bead. Changes in volume can be determined with accuracy as small as .01 cu. mm. of water when the capillary is accurately graduated.

Since the apparatus described was first made, Svedberg[5] has measured the hydration of gelatin by means of a dilatometer in which water and paraffin oil are used. The gelatin is held on a disc suspended by a wire which passes up through the capillary tube. After constant temperature is attained the gelatin is lowered by means of the wire into the lower layer of water. After the hydration of the gelatin the disc is raised to its former position. In this method there would be considerable chance of error. If the substance were wet by paraffin oil, hydration in many cases would be inhibited if not entirely prevented. Also corrections for the volume of the wire in the capillary would be necessary.

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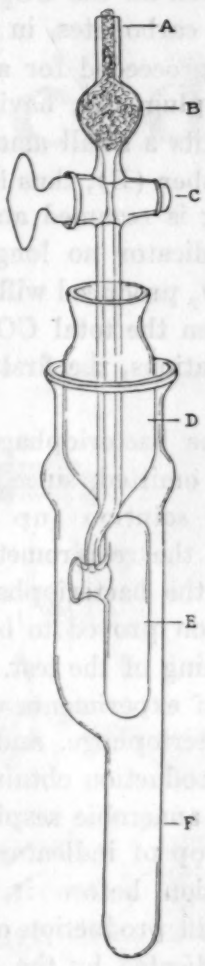
SPECIAL ARTICLES

DOES BACTERIOPHAGE RESPIRE?

As bearing on the discussion of the nature of bacteriophage, namely, whether it is a living virus or not, I reported failure to detect evidences of respiration such as should have occurred had the bacteriophage been a living organism.[1] The experiments were performed in a respirometer in which an initial volume of CO_2-free air was sent along a closed circuit[2] by means of a double action mercury pump, through a vessel containing the material which was to be studied. The production of CO_2, on the assumption that all volatile acid consisted of it, was estimated colorimetrically by the method of Ray.[3] In view of the failure to obtain evidence of respiration by bacteriophage, the question arose as to whether respiration had not been suppressed by mercury vapor, accumulating while the air was repeatedly passing through the pump. Although bacteria and tissue emulsions placed in the apparatus were not prevented from respiring and producing CO_2, the possible action of mercury had still to be considered, especially in view of the fact that while bacteria and tissues remained in the respirometer for minutes, or hours only, bacteriophage remained there for four days.[1] This difficulty has been overcome by using a recent suggestion of Parker,[4] namely, shaking of the respirometer in order to secure even distribution of gases. The method, as now employed, can, we believe, be advantageously used for the study of respiration of various micro-organisms, including the filtrable viruses, and in atmospheres of oxygen or of inert gases, at any desired pressure up to atmospheric.



The apparatus is shown in the diagram. It is loosely assembled (C and D), plugged with cotton (B), and sterilized by dry heat. After removal from the oven, a measured amount of bicarbonate and indicator[3] is run into the outer tube (F), and the material to be examined is placed in the inner tube (E), the ground joints (C and D) are smeared with sterile vaseline, and the parts pressed together, due precautions being taken to prevent bacterial contamination. The apparatus is now connected (at A) through a two-way stop-cock with a vacuum pump and with a wash bottle containing caustic soda, and delivering air free of CO_2, or an inert gas, and while being rocked is alternately exhausted with the pump and filled with CO_2-free air, until the color of the solution in the outer chamber (F) reaches that of the stand-

[5] *Jr. Amer. Chem. Soc.*, pp. 2673, Dec., 1924.

[1] Bronfenbrenner, J., *Proc. Soc. Exper. Biol. and Med.*, 22, 81, 1924.

[2] Osterhout, W. J. V., *Jour. Gen. Physiol.*, 1, 17, 1918.

[3] Ray, G. B., *Jour. Gen. Physiol.*, 6, 509, 1923.

[4] Parker, G. H., *Jour. Gen. Physiol.*, 7, 641, 1925.